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Evaluating Swine Drylot Runoff Impact on a Coastal Plain Stream

North Carolina State Univ. at Raleigh

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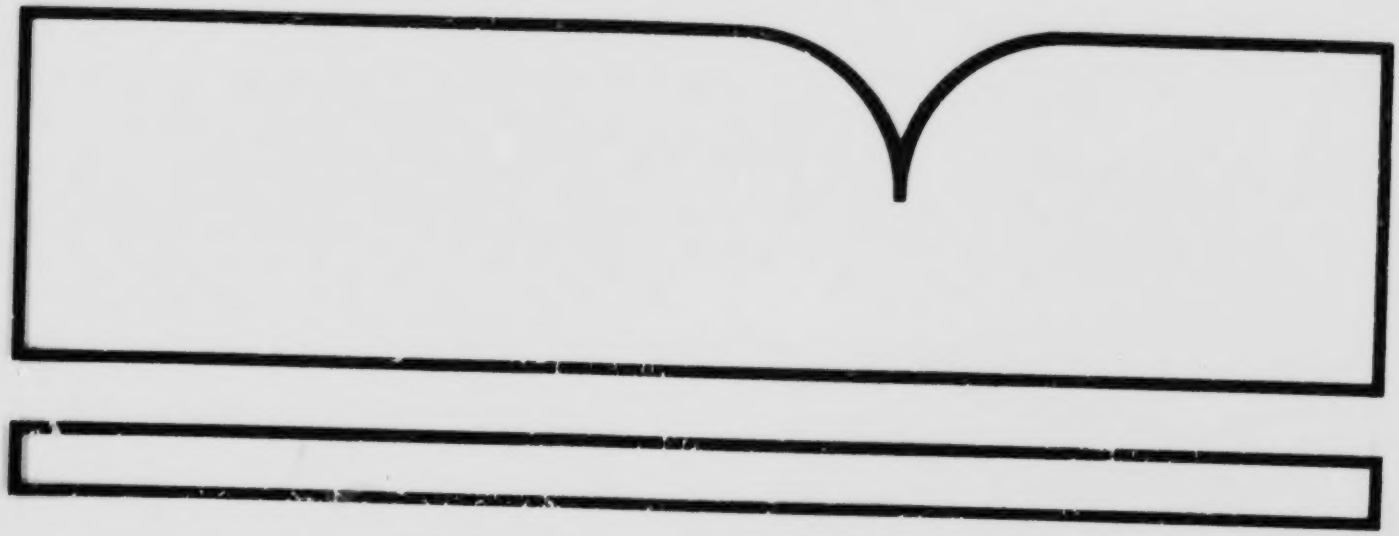

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EVALUATING SWINE DRYLOT RUNOFF IMPACT ON A COASTAL PLAIN STREAM

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16. ABSTRACT

The objectives of this study were to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality and to determine changes in stream water quality as a result of rainfall runoff from swine drylots on deep sands. The drylot studied annually markets approximately 4000 hogs on dirt lots with deep sandy soils and typifies physical and management factors common to Coastal Plain Swine production. Field results indicated that approximately 2% of the nutrient and organic load of the defecated swine wastes were transported from the sandy drylot surface in rainfall runoff. The constituent levels of this lot runoff were further reduced 20-to 40-fold by swamp and vegetative buffer filtering action prior to stream input.

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FOREWORD

EPA is charged by Congress to protect the Nation's land, air and water systems. Under a mandate of national environmental laws focused on air and water quality, solid waste management and the control of toxic substances, pesticides, noise, and radiation, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life. In partial response to these mandates, the Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, is charged with the mission to manage research programs to investigate the nature, transport, fate, and management of pollutants in ground water and to develop and demonstrate technologies for treating wastewaters with soils and other natural systems; for controlling pollution from irrigated crop and animal production agricultural activities; for controlling pollution from petroleum refining and petrochemical industries; and for managing pollution resulting from combinations of industrial/industrial and industrial/municipal wastewaters.

This project was initiated to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality and to determine chemical concentration changes in stream water quality as a result of rainfall runoff from swine drylots situated on deep sands. This information is useful in determining optimal practices which will lead to the development of Best Management Practices (BMPs).

Clinton W. Hall

Clinton W. Hall, Director
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ABSTRACT

The objectives of this study were: 1) to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality, 2) to determine chemical concentration changes in stream water quality as a result of rainfall runoff from swine drylots on deep sands by comparing these resultant stream concentrations with those from a background reach of stream, and 3) to determine any changes in the stream biota as a result of the drylot runoff.

A drylot unit was selected for investigation which annually markets approximately 4000 hogs on dirt lots with deep sandy soils and which typifies physical and management factors common to Coastal Plain swine production. Stream samples were collected at sites above, adjacent to, and downstream of the drylots and analyzed for chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO_3-N), total phosphorus (TP), and chlorides (Cl) over a 40-month period. These measurements as well as dissolved oxygen (DO) and stream flow were taken under low-flow conditions by grab sampling techniques while stream samples were collected under rainfall runoff conditions by instrumented sampling stations. Biological surveys of the stream flora and fauna were also conducted. These results are discussed as well as the study approach, site selection, and sampling methodologies.

Field results indicated that approximately 2% of the nutrient and organic load of the defecated swine wastes are transported from the sandy drylot surface during rainfall runoff. The constituent levels of this lot runoff are further reduced 10- to 40-fold by swamp and vegetative buffer filtering action prior to stream input. Background stream constituent concentrations were very similar to levels measured in geographically-similar well-drained Coastal Plain watersheds. Nutrient levels, except for phosphorus, below the drylot were similar to background levels under low-flow conditions. Nitrogen and chloride stream levels were approximately doubled by rainfall runoff from the drylot while phosphorus was elevated approximately 5-fold. Despite these nutrient level increases, however, no significant alteration of the stream biology was detected. It would appear from this study that more emphasis should be placed on the actual in-stream biological changes that may occur as a result of point-source and nonpoint source inputs to reinforce conclusions drawn from nutrient and organic measurements.

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LIST OF ABBREVIATIONS AND SYMBOLS

NPDES	-- National Pollution Discharge Elimination System
ha	-- hectare
VS	-- volatile solids
m	-- meter
kg	-- kilogram
km	-- kilometer
DO	-- dissolved oxygen
COD	-- chemical oxygen demand
TP	-- total phosphorus
TKN	-- total Kjeldahl nitrogen
NO_3-N	-- nitrate nitrogen
Cl	-- chlorides
cfs	-- cubic feet per second
mg/l	-- milligrams per liter
n	-- number of observations
$\bar{x}$	-- mean
s.d.	-- standard deviation
min	-- minimum value
max	-- maximum value
C.V.	-- coefficient of variation

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SECTION 1

INTRODUCTION

Effluent from farm animal production areas is proclaimed as a significant contributor to surface water pollution. Different climatic, geographic, soil, and vegetative conditions, as well as management practices, however, profoundly affect the quality and amount of rainfall runoff and resulting stream impact from these animal production units. Concerns arise, then, over the implementation of uniform national criteria for effluent guidelines and limitations for concentrated animal feeding operations as designated in the Federal Water Pollution Control Act Amendments of 1972 and the March 18, 1976 Federal Register. Regulatory criteria should be responsive to the needs and desire of the indigenous population as it supports national goals. The prudent balance between comprehensive regulations and criteria that are regionally responsive to both quality environment and food production must be maintained.

Decisions concerning control of rainfall runoff from animal production units in a specific location should include an evaluation of whether the constituents adversely affect the quality of a particular receiving water. It would be a misuse of resources to attempt complete control of any of these sources where they do not have an adverse effect or where such control will not produce a positive effect on water quality. Such decisions require more factual information on the magnitude of the waste inputs to a stream, the chemical and biological effects on in-stream water quality, and benefits and costs associated with control possibilities.

Open swine production facilities (drylots) on soils not supporting vegetation are classified as concentrated animal feeding operations subject to the criteria outlined in the National Pollutant Discharge Elimination System (NPDES) guidelines. Approximately 45% of the 3.1 million swine in North Carolina are grown on such drylot units since they represent the minimum housing investment. A large majority of these drylots are in the Coastal Plain section of eastern North Carolina on deep sandy soils. Since a producer may be able to finish up to three times as many hogs in an open lot system as he could afford in confined housing, he may have several hectares (ha) of drylots with stocking densities ranging from 500-1250 market hogs per ha. Stocking densities in this range quickly denude lots of vegetation and will eventually kill any trees within the confined area. Manure buildup and soil compaction are minimal since animal activity tends to keep the wastes well mixed with the sandy surface of the well-drained soils.

Drylots are rotated after one year's production to control disease and parasites and to allow rejuvenation of the soil surface. These lots are then seeded to grasses or allowed to remain fallow for at least two years before being put back into production. Large swine drylots characteristic of the Coastal Plain are usually located on sloping topography but separated from a drainageway or stream by a wooded or vegetated buffer strip. These streams are ill defined and often traverse through low-lying wet areas. The actual control of runoff contaminants is to a large extent affected through proper site selection and management practices.

The major objectives of this study were:

1. to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality.

2. to determine chemical concentration changes in stream water quality as a result of rainfall runoff from swine drylots on deep sands by comparing these resultant stream concentrations with those from a background reach of stream.

3. to determine any changes in the stream biota as a result of the drylot runoff.

SECTION 2

CONCLUSIONS

The results of 40 months of intensive field monitoring of a Coastal Plain stream receiving rainfall runoff from a swine drylot have indicated that although stream nutrient levels are elevated during rainfall events, the drylot is having minimal impact on the receiving stream biology.

1. Approximately 2% of the defecated swine wastes is transported from the sandy drylot surface during rainfall runoff. Nutrient and organic constituent levels of lot runoff are further reduced 10- to 40-fold by swamp and vegetative buffer filtering action.

2. Background stream constituent concentrations were very similar to levels measured in geographically-similar well-drained Coastal Plain watersheds. Nutrient levels, except for phosphorus, below the drylot were similar to background levels under low-flow conditions.

3. Surface runoff and tile drainage from row-crop land appears to have an equal or greater impact on stream nitrogen levels under low-flow conditions than drainage from the swine drylot. Nitrogen concentrations cycled seasonally with peaks during the wet winter months of low evapotranspiration and an additional spike shortly after spring fertilizer application.

4. Nitrogen and chloride stream levels were approximately doubled by rainfall runoff from the drylot while phosphorus was elevated approximately 5-fold. Despite these nutrient level increases, however, the effect on stream biological activity was very subtle and inconclusive based upon the data obtained.

5. Acquisition of flow data from sluggish, unstable Coastal Plain streams proved to be very difficult, costly and time-consuming rendering the cost benefits of obtaining such data questionable.

6. Benefits have already accrued from the cooperative effort of this investigation with the state regulatory agency. It has enhanced the working relationship between educational and regulatory agencies, and the livestock producer resulting in more logical implementation of regulations which are responsive to local conditions and needs, yet compatible with national water quality goals.

SECTION 3

RECOMMENDATIONS

Consideration should be given to the importance of mass transport and just how flow data will be used before expending the efforts necessary to obtain such information. Instrumentation in humid surroundings is particularly sensitive to moisture. Adequate ventilation should be provided and moisture absorbents used liberally.

Additional livestock production units under different soil-geoclimatic conditions should be similarly monitored in order that a predictive trend might be established.

More emphasis should be placed on the actual in-stream biological changes that occur as a result of point-source and nonpoint source inputs to reinforce conclusions drawn from the nutrient and organic levels of the receiving stream.

Cooperative efforts between university research and cooperative extension agencies, production unit management, and state regulatory agencies greatly enhances the value and work effort of a field investigation.

SECTION 4

STUDY APPROACH

This field evaluation was a joint effort between the North Carolina Agricultural Extension Service and Agricultural Experiment Station, Sampson County Cooperative Extension Service, North Carolina Department of Natural Resources and Community Development, and swine production unit management. Overall direction was provided by extension specialists and research faculty. Field work was coordinated by the responsible extension specialist and performed by technicians and local county extension personnel. The county extension agents were responsible for site and instrument maintenance, in-stream measurements and sample collection. Biological stream investigations were conducted by research specialists from the Environmental Management Division of the state regulatory agency.

This type of cooperative effort greatly enhances the value and work effort of a field investigation. By involving local extension workers and the production unit managers, enthusiasm for the project results in more complete work inputs. Project continuity is also maintained since the production unit being evaluated is remotely located from the research base. Cooperation between educational or service agencies and regulatory agencies makes the most cost-effective use of each area of expertise and enhances the working relationship for implementation of research results and on-site regulatory investigations.

It is recognized that good judgment must be exercised in generalizing the results from this study to other animal production sites. The most desirable situation would be to evaluate a number of production sites and compare results. However, in view of limited research resources and manpower, a trade-off exists between intensively monitoring one production unit which has been selected as representative of area production units or surveying a number of production units less intensively. Only one production unit was intensively monitored in the study reported herein so that more confidence could be placed in the results obtained. It is anticipated that the results of this study can be coupled with similar studies from other researchers so that a trend might be established.

In selecting a swine drylot for investigation, the following criteria were established as essential to the success of the study: 1) ability to completely define drainage and runoff, 2) ability to evaluate drylot impact on receiving stream by comparing a similar stream reach free of livestock and other point sources, 3) an operation that typified physical and management factors common to Coastal Plain drylots, and 4) a

cooperative producer who would allow use of his farm as an unbiased study site. After rather extensive surveillance of some 30 drylots, it became quickly apparent that such a "typical representative" drylot meeting all of these criteria did not exist. However, the unit selected most nearly meets these criteria and is felt to be representative of most swine drylots on deep sandy soils in the Coastal Plain.

SECTION 5

PREVIOUS AND CURRENT RELATED WORK

Loehr (1974) assessed various pollution sources for their relative characteristics and contributions to the environment. All source comparisons were presented in terms of precipitation or runoff concentrations rather than in terms of characteristics reaching surface waters. He noted that many of these characteristics can be altered during transport across adjacent land and during transport in creeks and streams. When the water quality data were compared in terms of concentration units, precipitation, forest land runoff, and surface irrigation return flow had comparable values. He concluded that the actual decisions concerning the control of pollutional sources should be made on the basis of the relative importance of the respective sources in specific locations and what is technically and logically controllable.

Humenik et al. (1978) statistically surveyed small subbasins in a large watershed to determine the feasibility of making areawide assessments of the magnitude and impact of rural runoff. Results from oxygen kinetic studies indicated that organic material entering these streams is biologically unavailable. Point-in-time and long-term average comparisons between headwater and estuarine chemical parameters showed small differences. Individual runoff events were judged to be more indicative of extreme concentration and mass transport impact than base flow conditions.

Campbell, Graetz, and Nordstedt (1977) studied the effects of different production systems of beef cows and calves at stocking rates greater than regular pasture systems, and in complete confinement, on ground water and surface water quality. Losses of nutrients in surface runoff and runoff nutrient concentrations from the study areas were relatively low indicating no serious water quality impacts.

Gilbertson et al. (1970) concluded from unpaved beef feedlot studies that runoff appeared to be more dependent on rainfall than on feedlot slope or cattle density. The amount of runoff resulting from rain depended mainly on the condition of the feedlot surface as determined by previous rainfall events, and rainfall intensity and duration. Waste concentrations in winter runoff were about 10 times that of rainfall runoff concentrations. Only about 3% of the volatile solids (VS) deposited on the feedlot surface were transported in runoff for lots with stocking rates of 9.3 m^2 per head. Little difference was noted

between different slopes and cattle densities for nitrogen and phosphorus in rainfall runoff.

Madden and Dornbush (1971) found that in a typical feedlot operation approximately 95% of the total waste produced is either removed by cleaning operations or decomposed on the feedlot surface. Potentially 5% of the total waste generated may leave the feedlot in surface runoff.

Wise and Reddell (1973) conducted a study of feedlot runoff from a 10,000 head feedlot. They concluded that the storm pattern and size had little effect on the average concentration of most chemical constituents, but an increase in slope of the drainage area tended to cause an increase in the concentration of the chemical elements. Concentrations of water quality parameters in the actual feedlot runoff did not change as much with variations in rainfall intensities, runoff rates, and runoff volumes as indicated by some laboratory simulated runoff studies.

Robbins, Howells, and Kriz (1971) illustrated the relative pollutional effects of manure disposal and pastured animals. They concluded that the extent of water pollution from farm animal production units is more dependent on waste management methods than on the volume of wastes involved. Points of animal concentration should be located away from streams and away from hillsides leading directly to streams. Even in cases where the disposal sites are poorly located or managed or where pastured animals have stream access, the amount of pollutants which reach streams is a very small proportion (less than 10%) of the potential from the farm animal wastes deposited in the watersheds.

Miner et al. (1966) investigated runoff from small paved and unpaved experimental feedlots using simulated rainfall. The concentration of carbonaceous and nitrogenous compounds varied with rainfall intensity, antecedent moisture conditions, temperature, and type of feedlot surface. Runoff from one natural storm produced a solids concentration much greater than those from the rainfall simulator.

SECTION 6

SITE DESCRIPTION

The farm selected for evaluation began finishing hogs in open dirt lots in 1974. Approximately 10,000 hogs were raised from feeder pig size (23 kg) to a market weight of 95 kg in 1976, the first year of this study, and about 8,500 head were finished in 1977. The steady-state capacity of the production unit fluctuates between 3-4000 hogs at an average live weight of 59 kg each or a total live animal weight of between 176,900-235,870 kg. Stocking densities range between 990-1240 head of swine per ha occupying a total drylot area of 2.8-3.2 ha.

The surface soils within these drylots are deep sands ranging in depth from 1.8-5.2 m overlying a clay subsoil. The lots occupy the crest of a ridge gently sloping (2-5%) toward a low-lying swampy area and are well drained. Vegetation within the lots at first animal occupation consists of native scrub timber which is killed within two years. After each year's production, animals are rotated to new lots. The old lots are then cleared of timber and sprigged with Coastal Bermuda grass.

The lower edge of the drylots is separated from a first-order stream (a stream which has only small unbranched, finger-tip tributaries) by approximately 15-23 m of thick woods and heavy native vegetation in a wet swampy area. The stream is ill defined and meanders through the swamp until it reaches a point approximately 90 m beyond the lowermost point of the drylots. At this point the soil type changes, swampy conditions cease, and the stream becomes well defined. A series of springs form the headwaters of the stream. The total drainage area to the confluence with a second-order stream is approximately 140 ha. Land uses within this watershed besides the swine drylot operation are mostly forested with some 14-16 ha of tile-drained row-crop land at the uppermost reaches of the basin.

SECTION 7

SAMPLING STRATEGIES

To accurately assess the organic and nutrient inputs to the receiving stream from the production unit, a decision was made to sample reaches of the stream above the drylots, as well as adjacent to them. The background reaches of the stream are free of point source inputs and drain forested and some row-crop land. These nonpoint source inputs can be subtracted from the constituent loadings of the stream reach adjacent to the drylot in order to determine the impact of runoff and drainage from the drylot itself. Figure 1 presents relative location of the sampling sites to the stream and drylots. Sampling site locations are also described in Table 1. Sites Nos. 1, 2, and 3 represent background conditions while Site 5 represents the first point downstream receiving runoff and drainage from the total swine production unit. The approximate distance between the stream headwaters and Site 5 is 0.8 km.

Also of interest in this study was whether or not stream constituent concentrations recovered or began approaching background concentrations at some distance downstream from the drylot. Sampling Site 6 is located on the receiving stream just prior to confluence with a second-order stream. A recovery reach of approximately 0.8 km exists between Sites 5 and 6.

Runoff from an individual pen of hogs was measured at the lowermost corner of the pen to determine the transport of nutrients from the drylot surface during runoff events. This pen was approximately 0.6 ha in size and contained 500 market hogs. Terraces around the outer edge of the pen channeled all runoff through a Parshall flume which was instrumented to measure flow and take runoff samples.

A grab sampling program was established in November 1975 at each of the six receiving stream sampling sites to evaluate stream constituent loadings under base-flow conditions. Samples were collected twice per month and preserved for chemical analysis. In-stream dissolved oxygen (DO) and flow measurements were also taken. Attempts were made to improve channel cross-sections and to increase velocity by channel restriction. The Ott current meter in conjunction with standard U.S. Geological Survey procedures was used since it has proven to give greater sensitivity than other types of flow meters under low-flow conditions (Humenik et al. 1978).

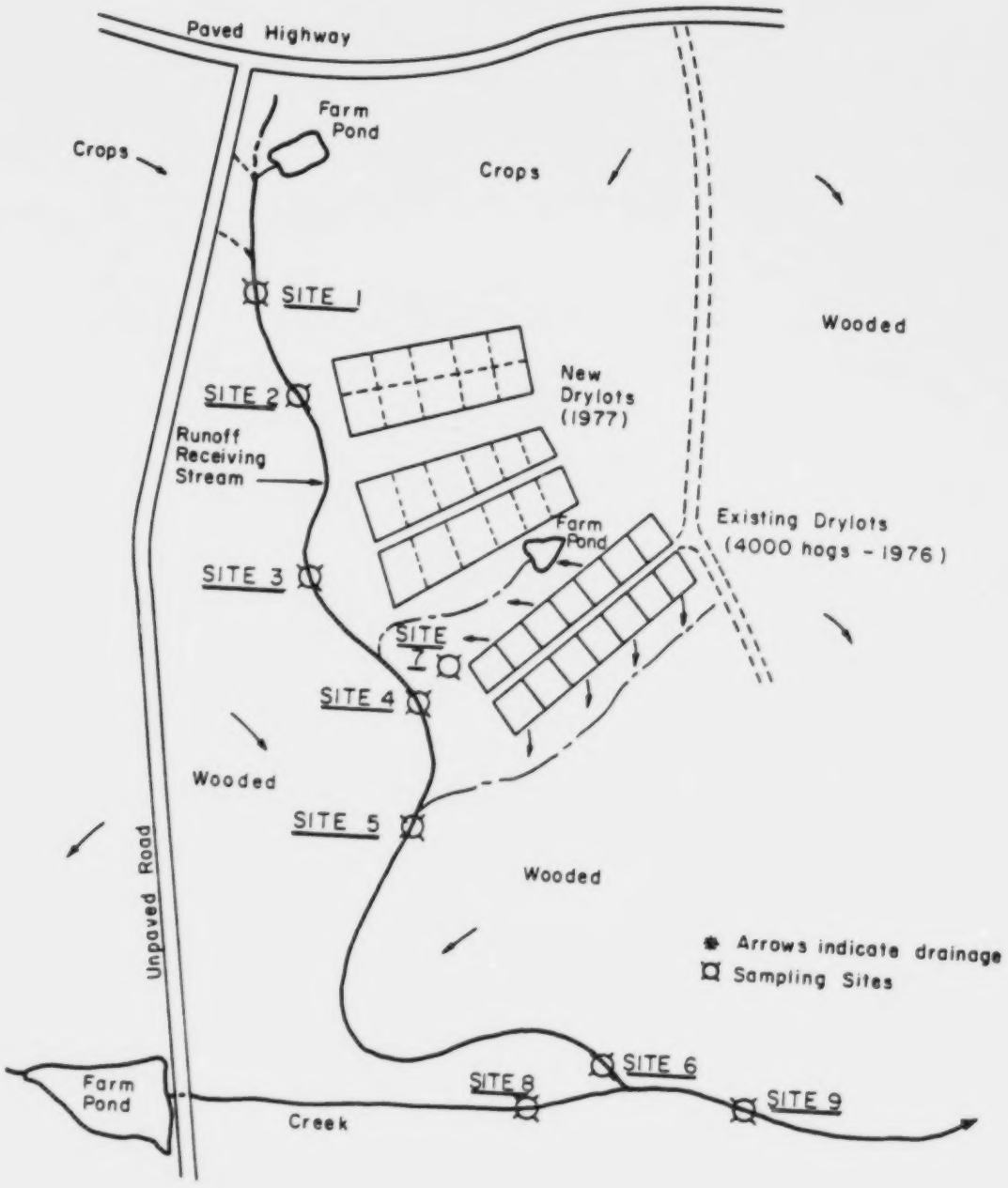

Figure 1. General site plan of swine drylots and stream sampling sites.

TABLE 1. SAMPLING SITE LOCATION AND DESCRIPTION

Sampling site no.	Site location	Site description
1	Receiving stream	Near headwaters; above drylot, buffered by swamp; drains some cropland
2	Receiving stream	Above drylot; buffered by swamp; drains woodland; used as background
3	Receiving stream	Above drylot; buffered by swamp; drains woodland; used as background
4	Receiving stream	Adjacent to drylots; buffered by swamp; receives some lot drainage
5	Receiving stream	Immediately below drylots; buffered by swamp; receives total drainage of drylot operation
6	Receiving stream	Approximately 0.8 km downstream of drylots; drains woodland
7	Drylot	Lower edge of individual lot; drainage from 0.6 hectare pen containing 500 hogs
8	2nd order stream	Upstream of confluence with receiving stream
9	2nd order stream	Downstream of confluence with receiving stream

INSTRUMENTATION

Instrumented sampling sites were installed on the receiving stream at Sites 1, 2 and 5 to assess constituent loadings during rainfall runoff events. Each instrumented station has a continuous strip-chart stage recorder and an automatic water sampler. The stage-discharge relationship is defined at some sites by improved channel cross-sections and by natural controls at other sites. It is calibrated at various stages of flow with the Ott current meter. The instrumented sites are visited weekly to retrieve any samples which might have been collected and to service the instruments.

The automatic water sampler is powered by a 12-volt automotive battery and collects 28 discrete samples. It is stage-activated by a float switch installed in the stilling well for the stage recorder. The sampler begins sample collection at a predetermined rise in stream stage

indicative of a runoff event and takes a discrete sample at 30-minute intervals until either the stream stage falls below that preset level or all 28 samples have been taken.

CHEMICAL ANALYSES

Grab samples were iced immediately after collection, then frozen by county extension personnel until pickup for transport to the North Carolina State University Biological and Agricultural Engineering laboratory for chemical analyses. Instrumented sample bottles were acid-fixed at the laboratory prior to being taken to the sampling site to preserve the samples after collection by acidifying them to a pH <2. These samples were also frozen after collection. Routine analytical determinations included COD, TP, TKN, NO_3-N, and Cl. Procedures were basically those of APHA (1971) with modifications for automation using the Technicon Auto Analyzer II (Technicon; 1973,1974), except for COD which was determined by the manual potassium dichromate reflux method with reflux time reduced to 30 minutes (Overcash et al., 1975).

BIOLOGICAL SURVEY

Biological investigations were conducted at each of the six sampling sites on the receiving stream plus two additional sites on the second-order stream upstream and downstream of the confluence. Each of these stations were examined seasonally in the months of April, July, and October during low-flow conditions and immediately after a rainfall runoff event.

The parameters investigated were periphyton, phytoplankton, benthic fauna, and macrophytes. Stationary in-stream glass slide periphytometers were used to give quantitative as well as qualitative periphyton (attached algae) results. Because of the shallow stream, a grab sample was collected at stream mid-depth to quantitatively analyze for phytoplankton using a Palmer-Mabney Nannoplankton Cell. Organisms retained by a U.S. Standard No. 30 sieve are referred to as "benthic macroorganisms" which are usually large enough to be seen by the unaided eye but are identified with the aid of at least a ten-power objective. Samples for this parameter were obtained by dredging one square foot of stream bottom using an Ekman dredge. Benthos were determined using Hester-Dendy multiplates. Macrophyton, all aquatic plants possessing a multicellular structure with cells differentiated into specialized tissues, were examined qualitatively by making visual observations and collection of representative types from the study area.

SECTION 8

RESULTS AND DISCUSSION

After trying several techniques for stage activation of the water samplers, the mechanical float switch has proven to be the most reliable. Attempts to make use of old and used stage level recorders were discarded in favor of acquiring newer Stevens Type A Model 71 recorders. Humidity within the sampling station created several problems with the instrumentation, especially the strip charts and the sensitive switching circuitry of the sampler. Adequate ventilation should be provided and moisture absorbents used liberally. In-stream flow measurements were often difficult to obtain due to the sluggishness and unstable organic bottom of the stream. These runoff flow measurement difficulties which continued throughout the study period resulted in sporadic and questionable flow data. Therefore, this report will emphasize the effects of constituent concentration changes on stream water quality. Flow rates under low-flow conditions are indicated in Figure 2 and approximate 0.1 cfs, 0.2 cfs, 0.4 cfs, and 0.45 cfs at the headwaters, background, below drylot, and recovery stream measuring points, respectively.

Average and extreme constituent concentrations are listed in Table 2 for each of the six sampling sites on the receiving stream under low-flow conditions. These averages represent approximately 50 grab samples or in-stream measurements taken over a 40-month period from November 1975 through April 1979. Dissolved oxygen levels are lowest near the headwaters of the stream. Since the stream is fed by springs and subsurface drainage, it has probably not traveled sufficient distances for complete surface oxygenation at Sites 1 and 2. Only a very slight oxygen sag occurs at the point receiving total drylot runoff and drainage (Site 5); but this DO concentration recovers and exceeds background levels (Site 3) through the downstream reach (Site 6). The minimum measured DO concentration below the swine drylot throughout the period of study was 4.0 mg/l which still meets water quality standards applicable to the surface waters of North Carolina. Figure 3 shows the seasonal cycling of the DO levels due to temperature variations.

Chemical oxygen demand concentrations are nearly doubled below the drylot increasing from a background of 23.02 mg/l to 44.80 mg/l at the point receiving total drylot runoff and drainage under low-stream flow conditions. COD levels (Figure 4) tended to fluctuate rather widely and the maximum values measured, except for one sampling date, were approximately the same below the drylot as they were above. This might be

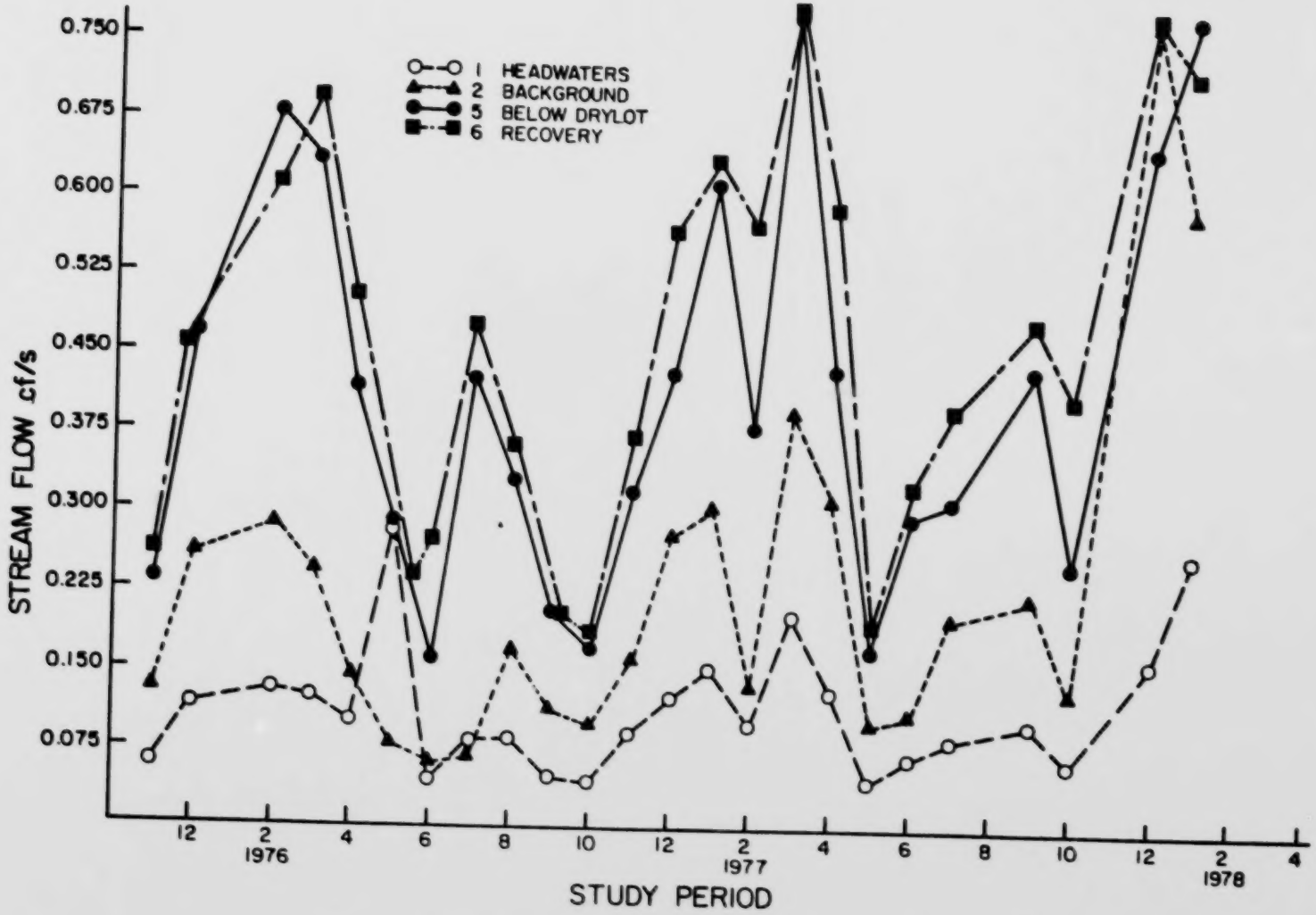

Figure 2. Receiving stream flow rates under low-flow conditions.

TABLE 2. MEAN CONSTITUENT CONCENTRATIONS OF RECEIVING STREAM UNDER LOW FLOW CONDITIONS

Water Quality Parameter	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
D.O., mg/l	4.3* 1.2 -10.2**	6.2 3.2 -11.9	8.4 4.9 -14.8	8.4 5.2 -13.9	7.0 4.0 -12.1	9.4 6.1 -15.2
COD, mg/l	27.12 11.76-75.10	23.02 3.93-49.43	24.44 7.53-79.04	32.84 11.86-72.24	44.80 15.81-100.97	39.48 15.75-75.10
TKN, mg/l	1.37 0.45-4.35	1.11 0.34-4.97	1.04 0.17-3.74	1.46 0.44-6.05	1.73 0.49-5.55	1.60 0.42-6.20
NO_3-N, mg/l	1.46 0.23-4.33	0.27 0 -2.00	0.12 0 -0.74	0.27 0 -1.60	0.49 0 -2.60	0.50 0 -2.48
TP, mg/l	0.13 0.02-0.43	0.07 0.02-0.15	0.09 0.02-0.20	0.18 0.04-0.38	0.41 0.09-1.35	0.38 0.12-0.78
Cl, mg/l	7.2 5.0 -12.1	5.9 4.0 -8.5	5.3 3.6 -6.8	5.8 2.7 -9.0	7.0 2.6 -12.6	7.1 2.7 -12.9
Flow, cfs	0.099 0.021-9.260	0.207 0.009-0.768	-***	-	0.404 0.076-1.062	0.458 0.091-0.923

*Mean of approximately 50 sampling dates over a 40-month study period.

**Range of values.

***Data not available.

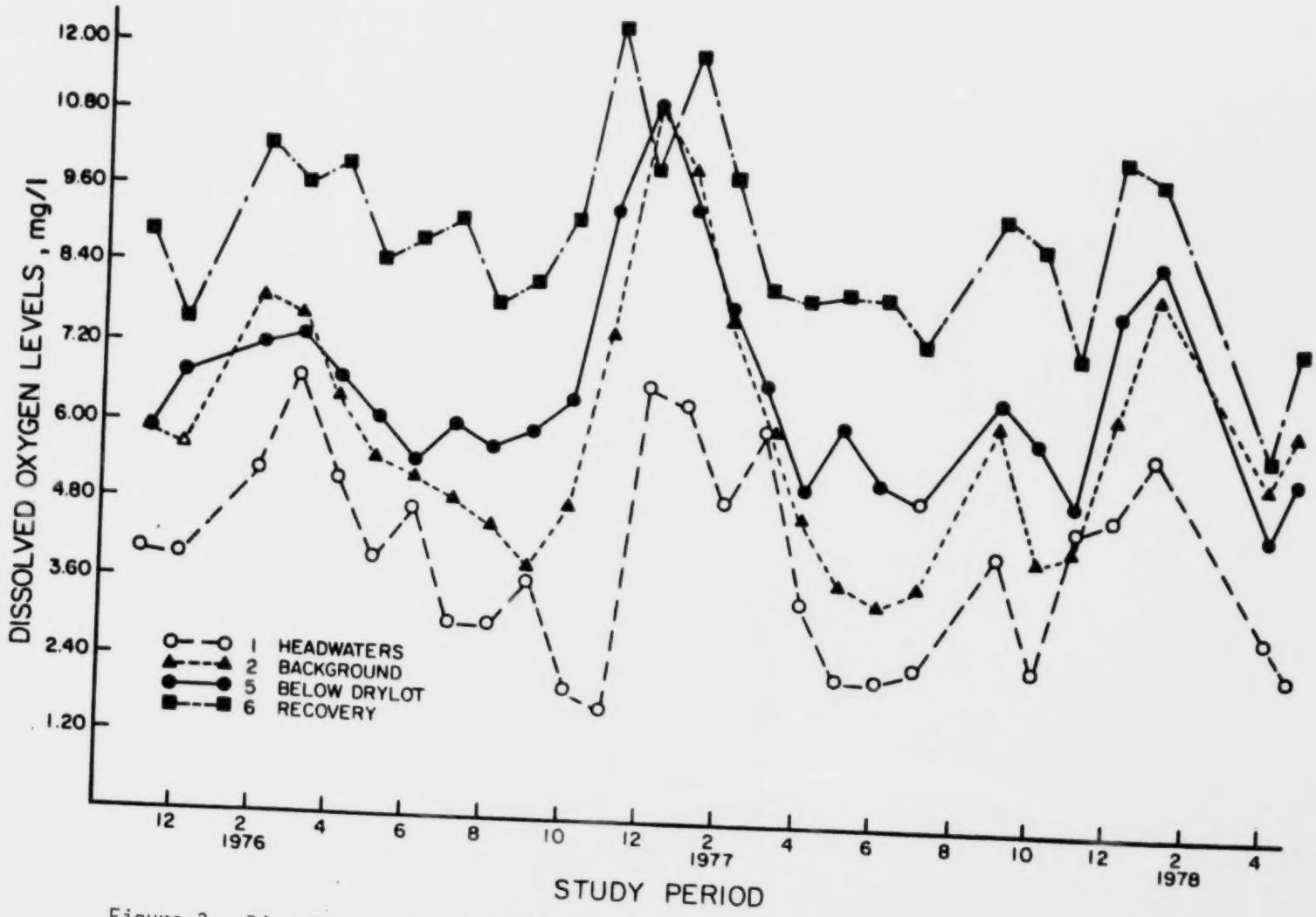

Figure 3. Dissolved oxygen concentrations of receiving stream under low-flow conditions.

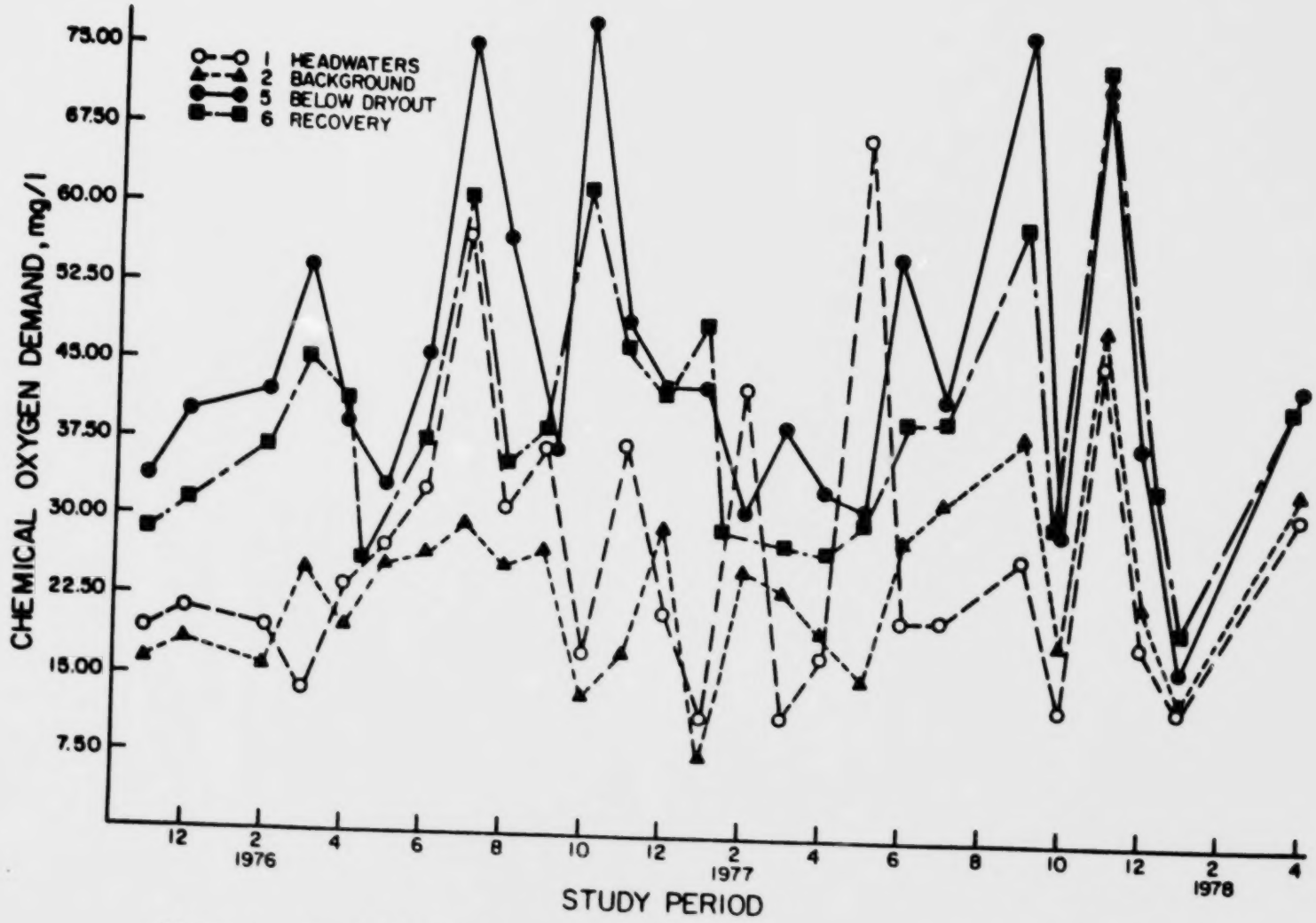

Figure 4. Chemical oxygen demand of receiving stream under low-flow conditions.

explained by the highly organic nature of the swamp which the stream drains. Little reduction of COD levels was observed through the downstream recovery reach (Site 6).

Individual rainfall runoff event statistics have been computed in Tables B-1 through B-15. The average coefficient of variation for COD, nitrogen, and TP levels during individual runoff events throughout the study period was approximately 30%. Reddell et al. (1975) reported that the arithmetic average of constituent concentrations for runoff from beef feedlots and land application plots over an individual hydrograph gives good consistent results which are essentially equivalent to a flow-weighted average concentration. Frere (1971) concluded that the concentration during each high water flow remained constant within the sampling variation. Thus all rainfall constituent concentrations reported in the text of this study have been arithmetically averaged over each runoff hydrograph. A typical hydrograph concentration for each constituent has been plotted in Figures C-1 through C-5. An extreme hydrograph concentration for each constituent is presented in Figures D-1 through D-5.

During rainfall runoff conditions, COD concentrations below the drylot increased by approximately 62% from 48.28 mg/l to 78.08 mg/l (Table 3, Figure 5). Runoff concentrations from the lot surface averaged 1521 mg/l COD with an extreme high of near 4000 mg/l. In terms of mass transport based on five runoff events, only approximately 2% of the raw waste defecated by the animals actually left the sandy lot surface during runoff. The concentrations of this lot runoff decreased by approximately 20-fold when compared to stream concentrations indicating the filtering capability of the swampy buffer between lot edge and stream, as well as dilutional effects.

Highest stream total nitrogen levels (TKN + NO_3-N) under low-flow conditions were measured near the headwaters (Figure 6 and 8). Total nitrogen levels were almost 2.5-fold higher at Site 1 than background levels at Site 3 and about 1.25-fold higher than the point at Site 5 receiving total drylot runoff and drainage (Table 2). Even greater relative differences were noted for NO_3-N with headwaters concentrations 12 times higher than background and 3 times higher than below the drylot.

These unanticipated results, upon closer scrutiny, may provide additional insight into nonpoint source stream inputs from drained row-crop lands in the Southeast. From Figure 6 a trend emerges showing seasonal cycling of the TKN concentrations under low-flow conditions.

The NO_3-N values (Figure 8) also support this trend with peaks particularly pronounced for the headwaters site (Site 1). The peak of the cycle occurs around January through March of each year with an additional spike in May. This would indicate that during the growing season nitrogen losses are reduced due to crop uptake and less moisture for soil-water transport, but after harvest more nitrogen becomes available due to residue decomposition and less evapotranspiration resulting in greater soil-water transport. The additional spike in May occurs after spring

TABLE 3. MEAN CONSTITUENT CONCENTRATIONS OF DRYLOT RUNOFF AND RECEIVING STREAM UNDER RAINFALL RUNOFF CONDITIONS

Water Quality Parameter	Sampling Site			
	Headwaters 1	Background 2	Below Drylot 5	Drylot Runoff 7
COD, mg/l	26.77*	48.28	78.08	1521.
	3.90-180.54**	10.00-166.03	29.00-577.00	403-3946.
TKN, mg/l	1.12	1.46	2.61	105.
	0.15-4.59	0.45-4.88	0.75-21.01	49.8-204.
NO_3-N, mg/l	1.36	0.49	1.77	7.25
	0 -3.70	0 -2.76	0 -8.60	0.03-26.80
TP, mg/l	0.10	0.13	0.74	31.00
	0.04-0.50	0.04-0.53	0.16-10.13	8.40-54.00
Cl, mg/l	7.76	6.37	10.13	96.6
	3.00-14.40	4.00-10.90	4.00-19.00	50.6-169.

*Mean of approximately 40 rainfall runoff events over a 30-month period.

**Range of values.

fertilizer applications. Similar results for fertilizer nitrogen transport in North Carolina were reported by Gilliam, Skaggs, and Weed (1978).

Total nitrogen levels below the drylot during base flow conditions are nearly double background level (Site 3) while NO_3-N increases 4-fold. These downstream nitrogen levels, however, are still comparable to those measured in a geographically-similar watershed free of point source inputs by Humenik et al. (1978) as indicated in Table 4. During rainfall runoff total nitrogen levels (Table 3) below the drylot were nearly 2.25 times higher than background levels (Figure 7 and 9). Pen drainage averaged 112 mg/l total nitrogen indicating a 25-fold decrease in concentrations after swamp filtering, denitrification and stream dilution.

The most notable, as well as most difficult to explain, difference in downstream chemical constituent levels when compared to background is total phosphorus. These concentrations (Table 2, Figure 10) are increased 4.5-fold over background levels during low-flow and are 3.5-fold higher than values for similar watersheds in this area (Table 4) reported by Humenik et al. (1978). A 6-fold increase over background occurs during rainfall runoff (Table 3, Figure 11). These runoff levels are approximately 1.8 times greater than low-flow concentrations. Pen drainage TP

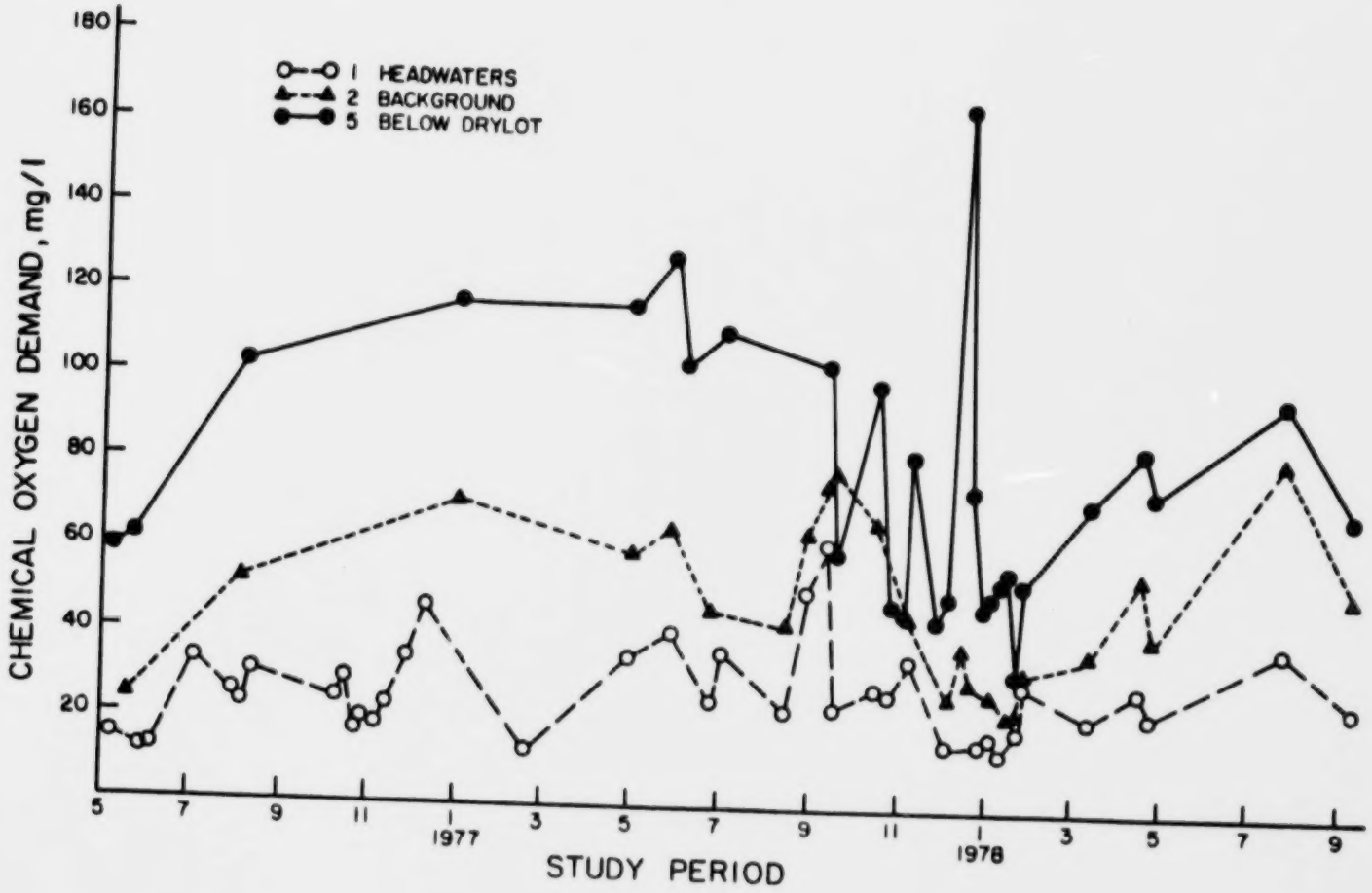

Figure 5. Mean chemical oxygen demand of receiving stream during rainfall runoff events.

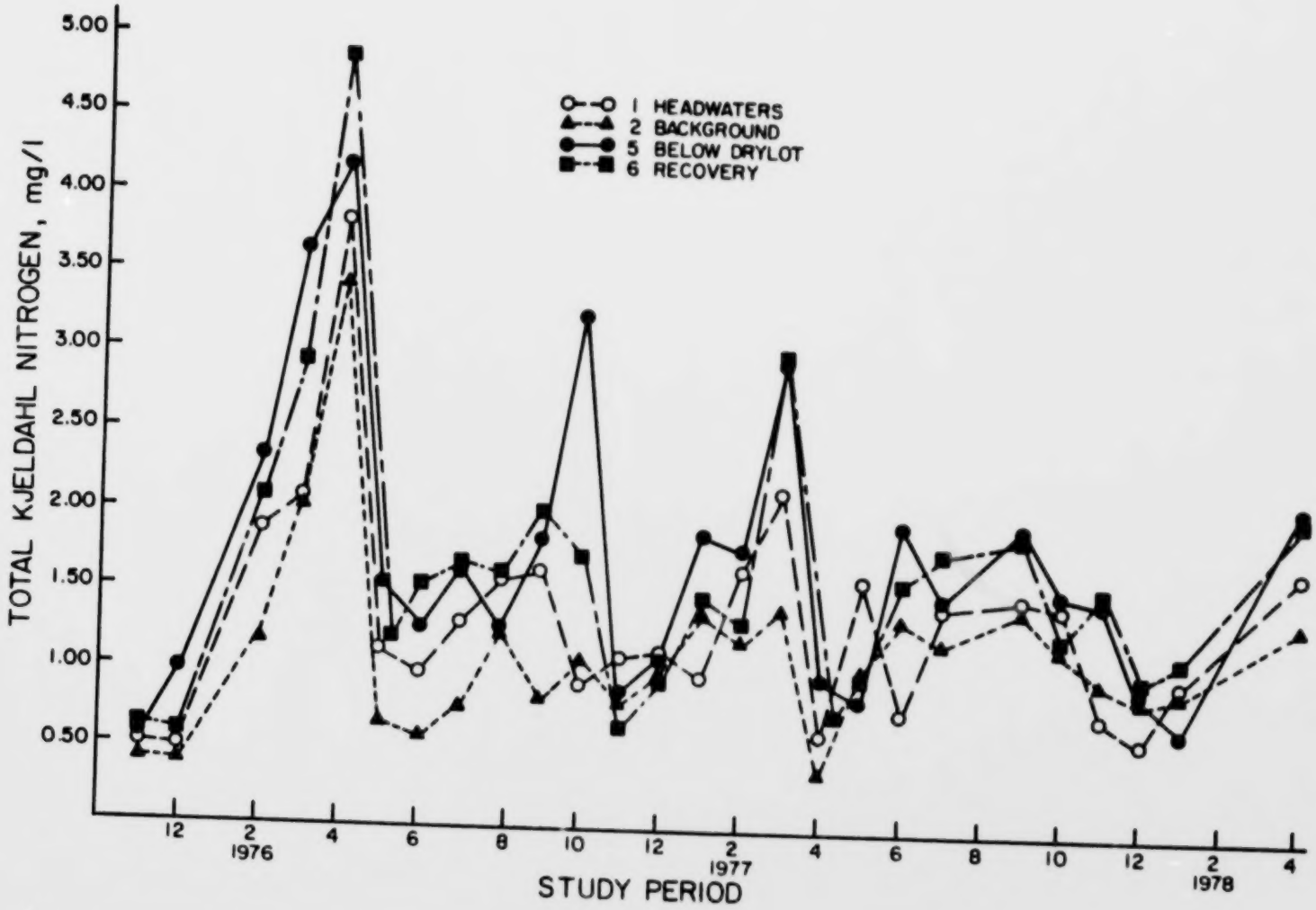

Figure 6. Total Kjeldahl nitrogen concentrations of receiving stream under low-flow conditions.

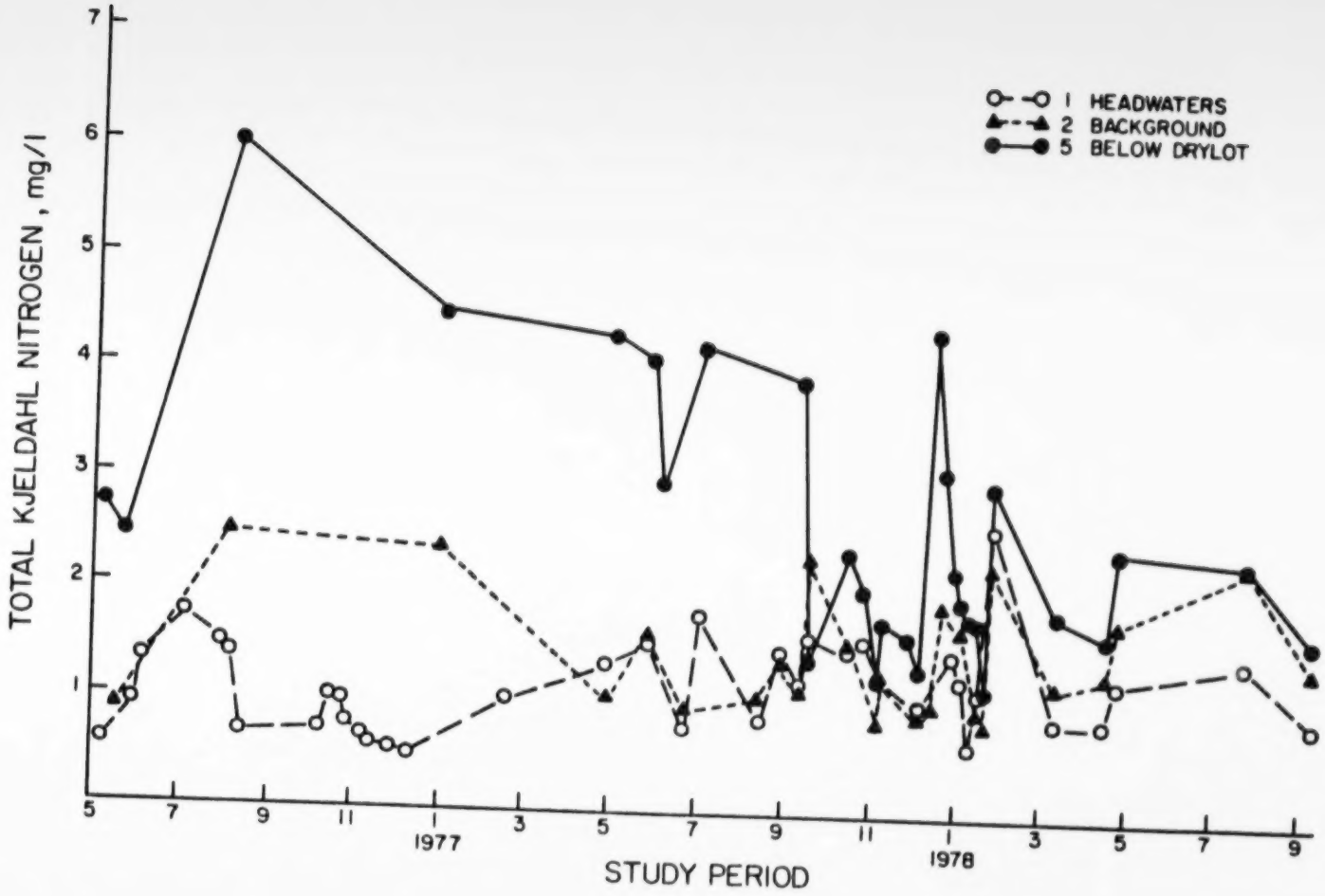

Figure 7. Mean total Kjeldahl nitrogen concentrations of receiving stream during rainfall runoff events.

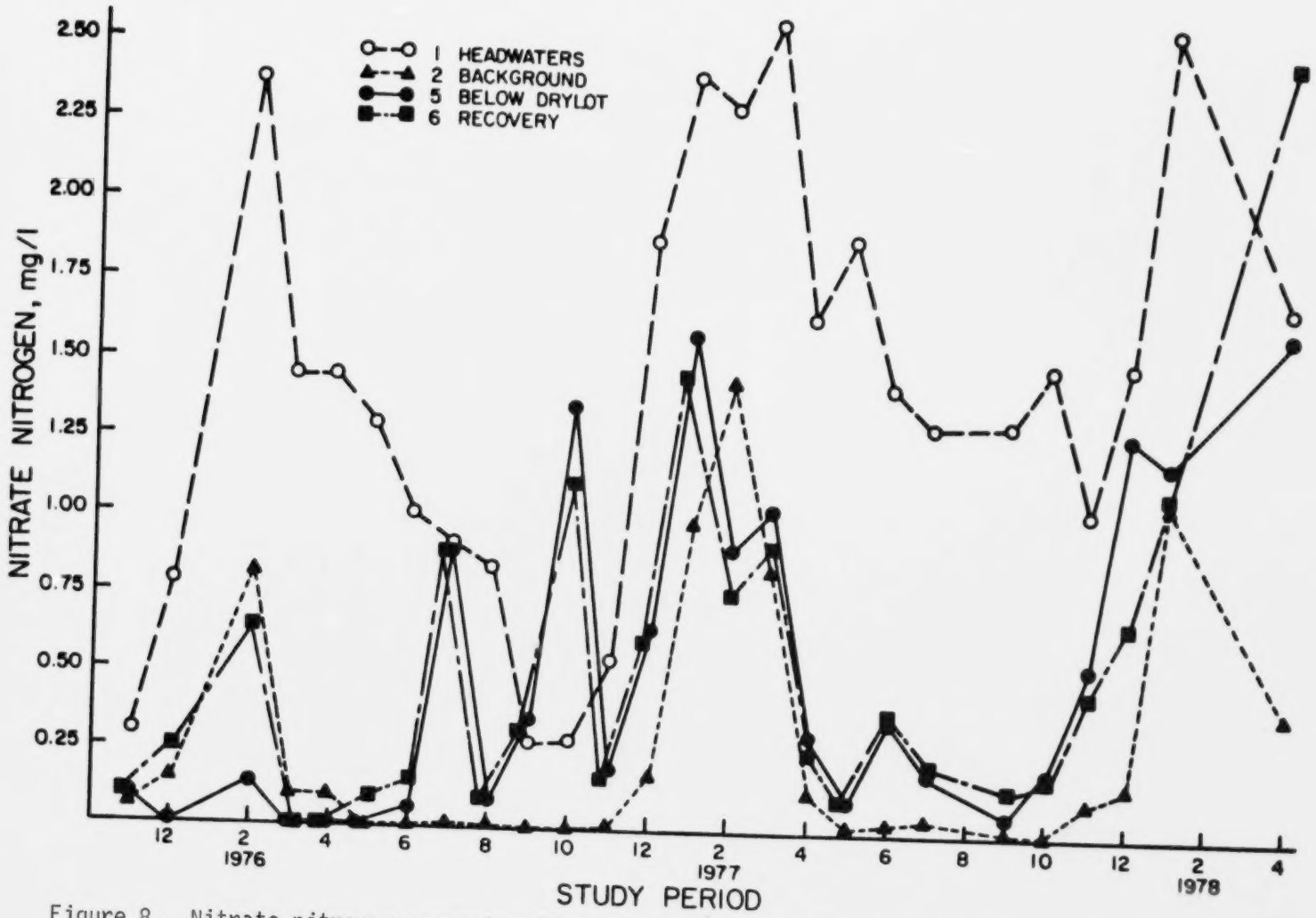

Figure 8. Nitrate nitrogen concentrations of receiving stream under low-flow conditions.

TABLE 4. MEAN CONSTITUENT CONCENTRATION COMPARISONS OF DRYLOT RUNOFF RECEIVING STREAM WITH SIMILAR N.C. WATERSHED STREAMS

Water quality parameter	Forested Piedmont*	Well-drained Coastal Plain**	Swine drylot			
			Low flow		Rainfall runoff	
			Background 2	Below drylot 5	Background 2	Below drylot 5
COD, mg/l	22.60	27.90	23.02	44.80	48.28	78.08
TKN, mg/l	1.10	1.28	1.11	1.73	1.46	2.61
NO_3-N, mg/l	0.04	0.57	0.27	0.49	0.49	1.77
TN, mg/l	1.14	1.85	1.38	2.22	1.95	4.38
TP, mg/l	0.12	0.11	0.07	0.41	0.13	0.74
Cl, mg/l	4.51	8.15	5.90	7.00	6.37	10.13

*Predominantly forested watershed similar in land use as reported by Humenik et al. (1978).

**Geographically-similar watershed as reported by Humenik et al. (1978).

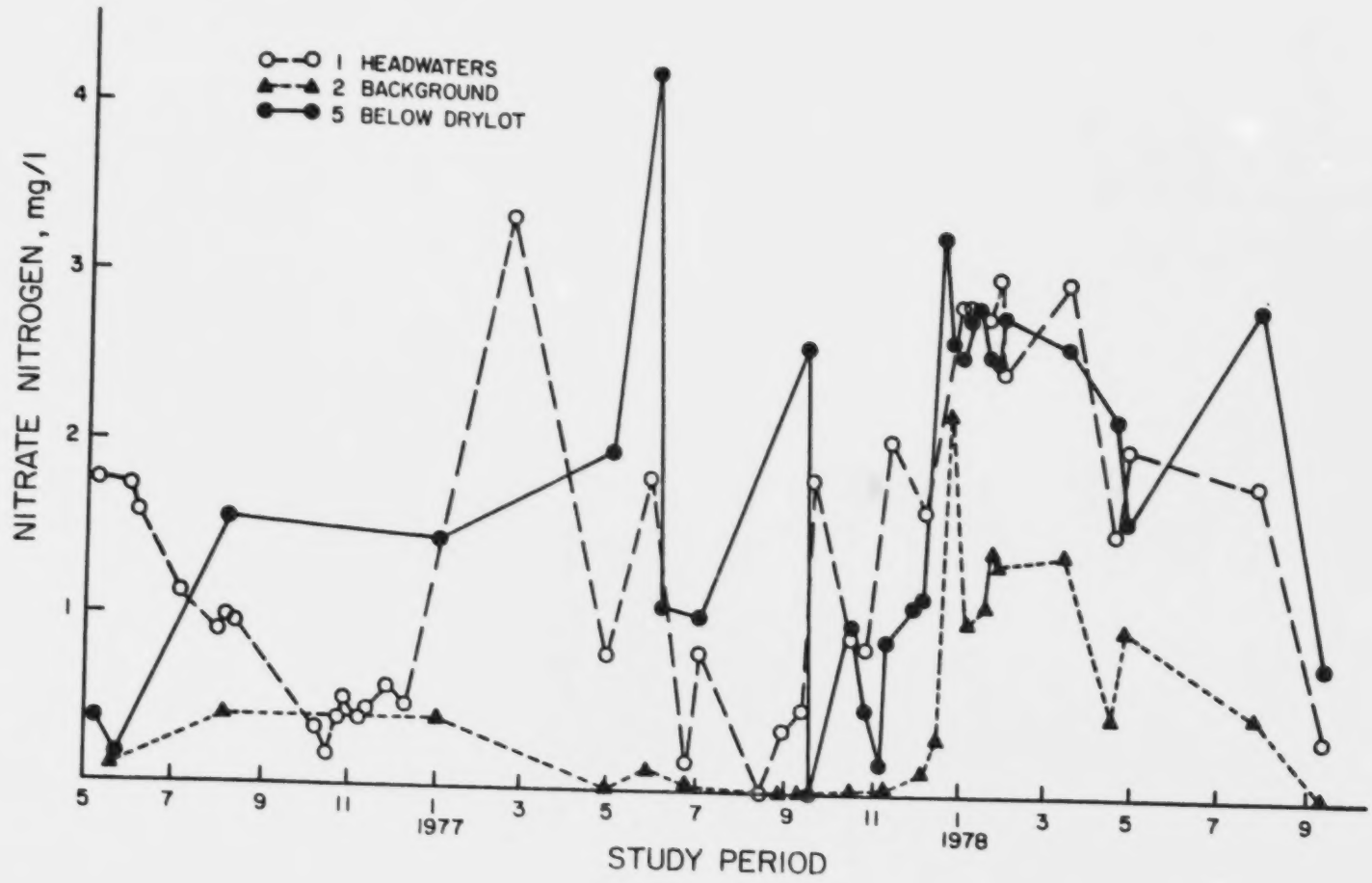

Figure 9. Mean nitrate nitrogen concentrations of receiving stream during rainfall runoff events.

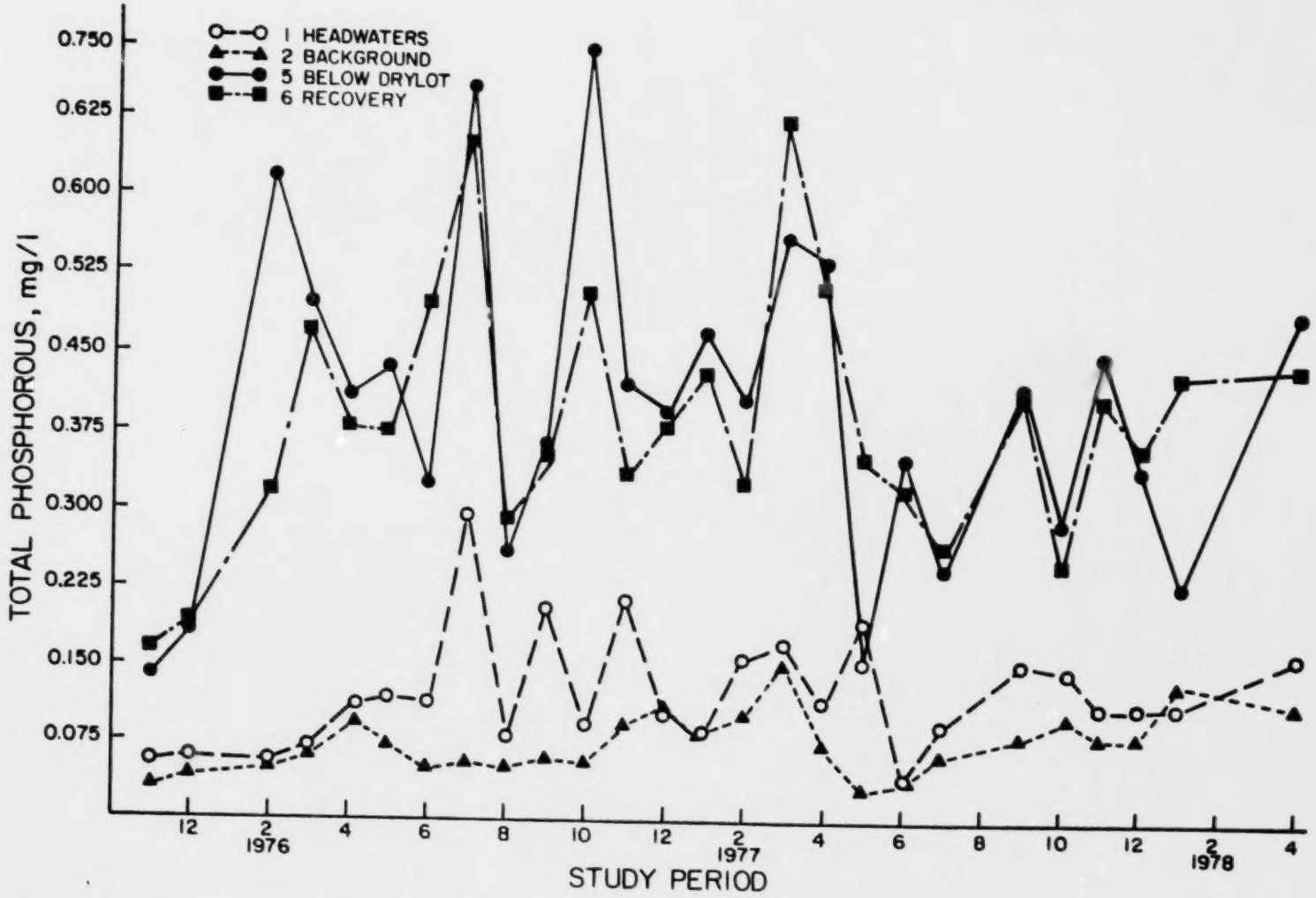

Figure 10. Total phosphorus concentrations of receiving stream under low-flow conditions.

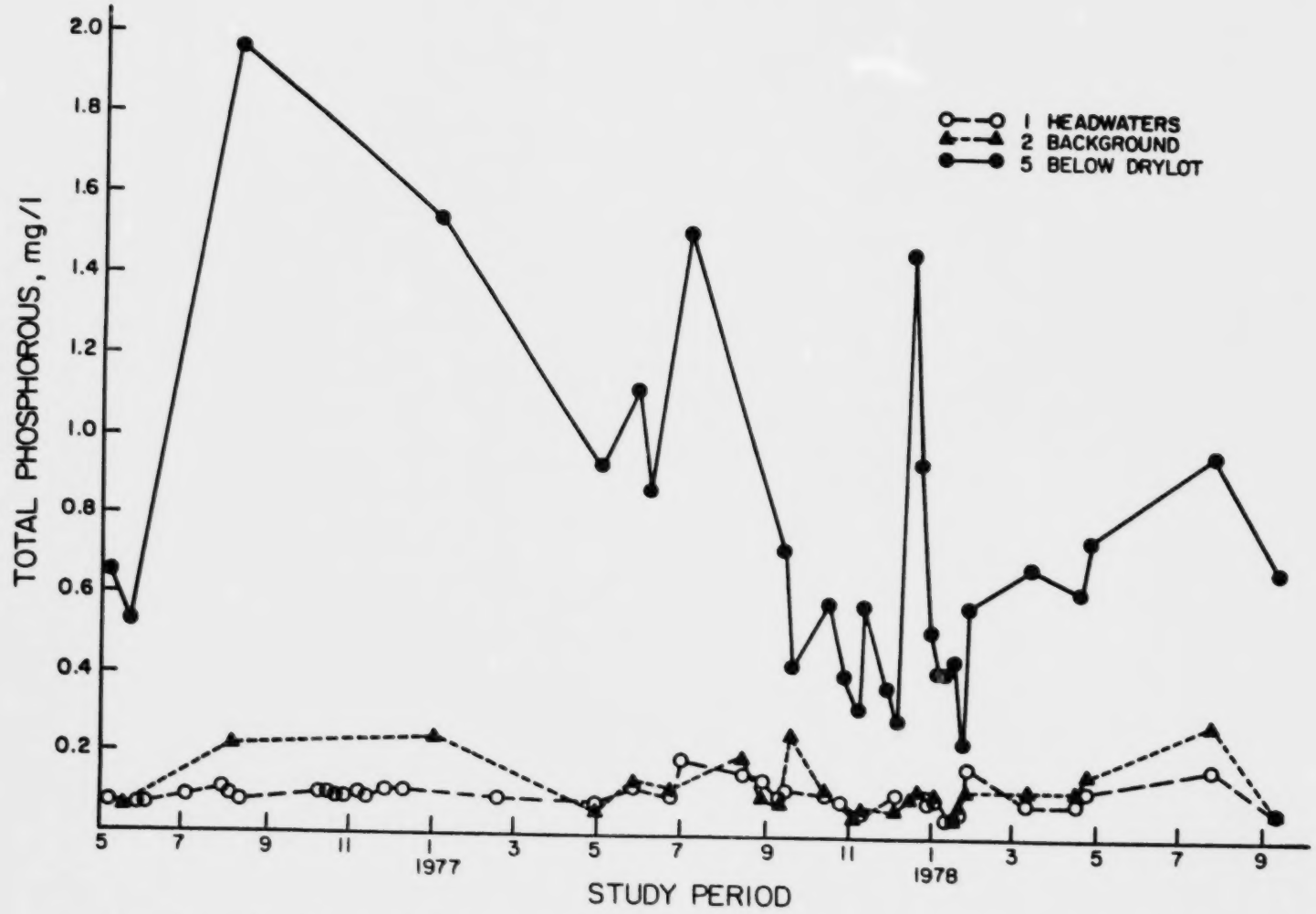

Figure 11. Mean total phosphorus concentrations of receiving stream during rainfall runoff events.

levels average 31 mg/l representing a 40-fold decrease between lot runoff and stream concentrations. Visual inspection of the stream channel indicates that most of the sediment transported from the lot in runoff is settled or trapped by the swamp buffer before it reaches the stream. One explanation is that the organic wastes leaving the lot surface also settle in the swamp where the phosphorus content of that waste is gradually and continually released to the stream through drainage and subsurface flow.

Little difference was noted in the stream Cl concentrations under low-flow conditions (Table 2, Figure 12) with the headwaters (Site 1), below drylot (Site 5), and recovery reach (Site 6) only slightly higher than background (Site 3). Levels at all sites were less than those reported for geographically similar watersheds by Humenik et al. (1978). A 1.6-fold increase in stream Cl concentrations was noted below the drylot when compacted to background under rainfall runoff conditions (Table 3, Figure 13). Pen runoff Cl levels averaged 96.6 mg/l and were reduced 10-fold when compared to stream levels.

BIOLOGICAL SURVEY

Results of the biological survey of stream periphyton under low-flow (three dates) and rainfall runoff (two dates) conditions, and of stream benthos under low-flow (three dates) conditions are presented in Tables 5-7. The occurrence and amount present of the various species of periphyton and various genera of benthos varies from date to date and site to site. In an attempt to better quantify the variation from site to site, the occurrence levels were assigned a numerical value as follows: dominant - 5; abundant - 4; common - 3; few - 2; present - 1. These population index values were summed for each site for each data. The total population index averaged for the three (or two) dates for the various sites are shown in Figure 14. It appears that for low-flow conditions both the periphyton and benthos show some decrease at Site 6. However, the population at Site 6 is similar or greater than at Site 8, which is typically less than at Site 9.

When the total population index is divided by the number of species or genera present for each date and then averaged over the two or three dates, the periphyton generally show a decrease in unit population index average per species or genus from Site 4 to Sites 5 and 6 (Figure 15). If the number of different species or genera present are summed for each date and averaged over the two or three dates, the benthos appear to show some decrease at Sites 5 and 6 and the periphyton some decrease at Site 6 (Figure 16). However, the indexes of biological activity presented in Figures 14-16 are variable and any effects of the drylot on stream biological activity are rather subtle and inconclusive. Thus the drylot runoff had a more measurable effect on the chemical water quality of the stream than on the biological activity indicators which were measured.

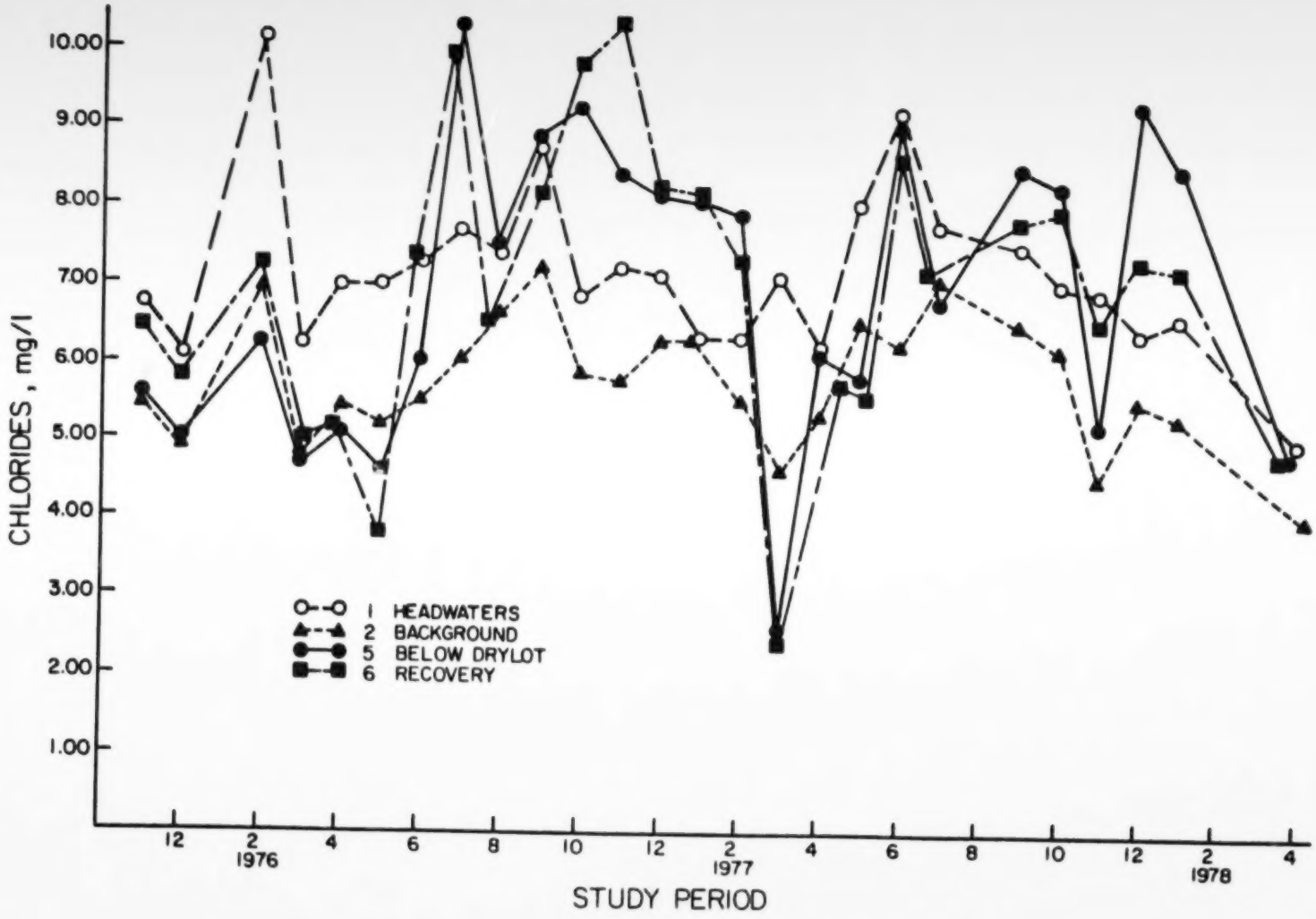

Figure 12. Chlorides concentrations of receiving stream under low-flow conditions.

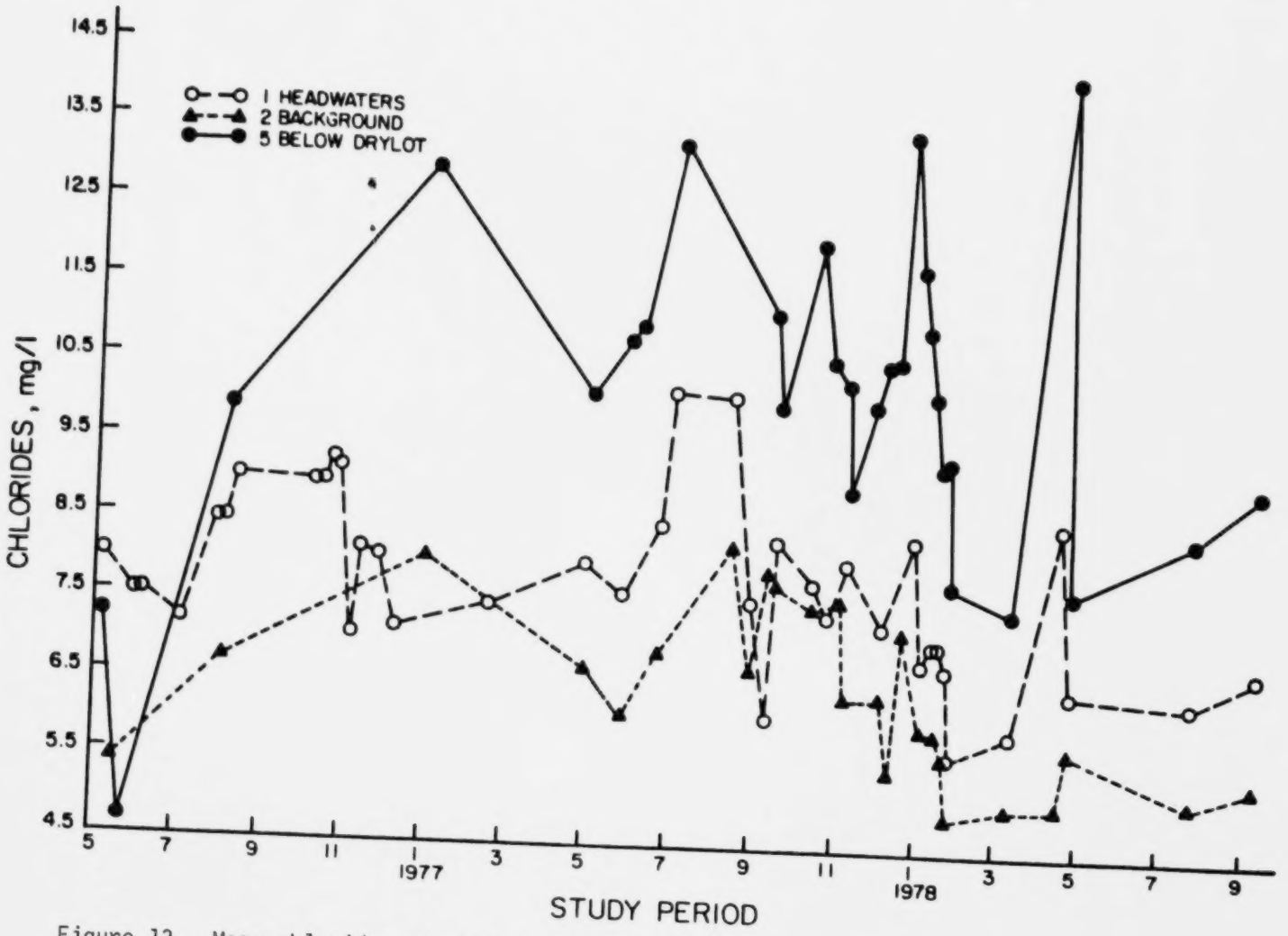

Figure 13. Mean chlorides concentrations of receiving stream during rainfall runoff events.

TABLE 5. BIOLOGICAL OCCURRENCE OF STREAM PERIPHYTON UNDER LOW-FLOW CONDITIONS

Species	Class	Occurrence		
		4/20/76	7/20/76	10/5/76
Site #1				
Spirogyra fluviatilis	Chlorophyceae	dominant*	-	dominant
Gomphonema vibrio	Bacillarieae	abundant	few	few
Cymbella lanceolata	Bacillarieae	abundant	-	-
Cymbella gracilis	Bacillarieae	-	-	common
Pinnularia viridis	Bacillarieae	common	few	-
Ankistrodesmus falcatus	Chlorophyceae	common	present	few
Achnanthes lanceolata	Bacillarieae	few	-	-
Fragilaria sp.	Bacillarieae	-	present	few
Oscillatoria limosa	Myxophyceae	-	few	present
Surirella sp.	Bacillarieae	-	present	-
Amphora ovalis	Bacillarieae	-	present	-
Chlorella sp.	Chlorophyceae	-	present	-
Site #2				
Spirogyra fluviatilis	Chlorophyceae	dominant	-	-
Schizomeris sp.	Chlorophyceae	-	-	dominant
Fragilaria sp.	Bacillarieae	abundant	few	common
Tabellaria sp.	Bacillarieae	abundant	-	common
Nitzschia subtilis	Bacillarieae	abundant	-	-
Trichodesmium laucustre	Myxophyceae	abundant	-	-
Navicula gracilis	Bacillarieae	common	-	-
Amphora coffaeformis	Bacillarieae	-	-	common
Surirella sp.	Bacillarieae	few	-	-
Dactylococcopsis musicola	Chlorophyceae	few	-	-
Desmidium grevillii	Chlorophyceae	few	-	-
Pinnularia viridis	Bacillarieae	-	few	-
Gomphonema vibrio	Bacillarieae	present	-	few
Stauroneis sp.	Bacillarieae	-	-	few
Oscillatoria limosa	Myxophyceae	-	few	-
Anabaena sp.	Myxophyceae	-	present	-
Ankistrodesmus falcatus	Chlorophyceae	present	-	-
Coelastrum microporum	Chlorophyceae	-	present	-
Site #3				
Spirogyra fluviatilis	Chlorophyceae	dominant	-	-
Schizomeris sp.	Chlorophyceae	-	-	dominant
Tabellaria sp.	Bacillarieae	abundant	present	common
Nitzschia subtilis	Bacillarieae	-	-	abundant

(continued)

TABLE 5 (continued)

Species	Class	Occurrence		
		4/20/76	7/20/76	10/5/76
Fragilaria sp.	Bacillarieae	common	common	abundant
Trichodesmium laucustre	Myxophyceae	-	-	abundant
Batrachospermum sp.	Rhodophyceae	-	abundant	-
Desmidium grevillii	Chlorophyceae	common	-	-
Gomphonema vibrio	Bacillarieae	present	few	common
Surirella sp.	Bacillarieae	few	-	-
Navicula gracilis	Bacillarieae	few	-	-
Amphora coffaeformis	Bacillarieae	-	-	few
Dactylococcopsis musicola	Chlorophyceae	few	-	-
Schroederia sp.	Chlorophyceae	-	present	-
Site #4				
Fragilaria sp.	Bacillarieae	dominant	dominant	common
Pinnularia viridis	Bacillarieae	abundant	few	few
Oscillatoria splendida	Myxophyceae	-	abundant	-
Tabellaria fenestrata	Bacillarieae	common	-	common
Stauronesis sp.	Bacillarieae	-	few	-
Navicula gracilis	Bacillarieae	-	-	few
Spondylosium moniliforme	Chlorophyceae	few	-	-
Surirella sp.	Bacillarieae	present	-	present
Palmella sp.	Chlorophyceae	present	-	-
Closterium lunula	Chlorophyceae	present	-	present
Site #5				
Fragilaria sp.	Bacillarieae	abundant	abundant	common
Navicula radiosa	Bacillarieae	common	-	-
Tabellaria fenestrata	Bacillarieae	common	few	-
Diatoma elongatum	Bacillarieae	common	-	-
Pinnularia viridis	Bacillarieae	-	common	common
Eunotica glacialis	Bacillarieae	-	few	-
Stauronesis sp.	Bacillarieae	-	few	few
Ankistrodesmus falcatus	Chlorophyceae	few	-	-
Closterium lunula	Chlorophyceae	present	-	few
Surirella sp.	Bacillarieae	present	present	present
Brebissonia boeckii	Bacillarieae	present	-	-
Achnanthes microcephala	Bacillarieae	-	present	-
Site #6				
Fragilaria sp.	Bacillarieae	dominant	few	-
Tabellaria fenestrata	Bacillarieae	abundant	few	common

(continued)

TABLE 5 (continued)

Species	Class	Occurrence		
		4/20/76	7/20/76	10/5/76
Pinnularia viridis	Bacillarieae	common	-	few
Navicula gracilis	Bacillarieae	few	-	present
Cymbella lanceolata	Bacillarieae	few	-	-
Achnanthes microcephala	Bacillarieae	-	few	-
Cosmarium bioculatum	Chlorophyceae	few	-	-
Ankistrodesmus falcatus	Chlorophyceae	few	-	-
Trichodesmium lacustre	Myxophyceae	present	-	-
Stauronesis sp.	Bacillarieae	-	present	-
Batrachospermum sp.	Rhodophyceae	-	-	present
Site #8				
Oscillatoria limosa	Myxophyceae	abundant	-	common
Stauroneis sp.	Bacillarieae	common	common	few
Tabellaria fenestrata	Bacillarieae	common	present	present
Pinnularia viridis	Bacillarieae	few	-	common
Pinnularia biceps	Bacillarieae	-	common	-
Fragilaria sp.	Bacillarieae	few	-	few
Navicula radiosa	Bacillarieae	-	few	-
Gomphonema vibrio	Bacillarieae	-	few	-
Cymbella lanceolata	Bacillarieae	-	few	-
Spondylosium moniliforme	Chlorophyceae	few	-	-
Site #9				
Oscillatoria limosa	Myxophyceae	dominant	common	common
Stauroneis sp.	Bacillarieae	abundant	dominant	few
Pleurosigma stringosum	Bacillarieae	-	abundant	-
Fragilaria sp.	Bacillarieae	common	abundant	-
Navicula radiosa	Bacillarieae	common	-	-
Gomphonema vibrio	Bacillarieae	-	common	-
Pinnularia biceps	Bacillarieae	-	common	-
Pinnularia viridis	Bacillarieae	few	-	present
Epithemia zebra	Bacillarieae	few	-	-
Tabellaria fenestrata	Bacillarieae	few	few	few
Cymbella lanceolata	Bacillarieae	-	few	-
Spondylosium moniliforme	Chlorophyceae	few	-	-
Staurastrum muticum	Chlorophyceae	-	few	-
Closterium lunula	Chlorophyceae	-	few	-
Staurastrum limneticum	Chlorophyceae	present	-	-
Navicula gracilis	Bacillarieae	-	-	present
Surirella sp.	Bacillarieae	-	-	present

*Respective order of occurrence frequency — Most frequent to least frequent: dominant-abundant-common-few-present

TABLE 6. BIOLOGICAL OCCURRENCE OF STREAM PERIPHYTON AFTER RAINFALL RUNOFF EVENTS

Species	Class	Occurrence 4/28/76	Occurrence 7/30/76
Site #1			
Spirogyra fluviatilis	Chlorophyceae	dominant*	-
Cymbella lanceolata	Bacillarieae	common	-
Pinnularia viridis	Bacillarieae	few	present
Oscillatoria limosa	Myxophyceae	-	few
Gomphonema vibrio	Bacillarieae	-	few
Ankistrodesmus falcatus	Chlorophyceae	present	-
Surirella sp.	Bacillarieae	-	present
Fragilaria sp.	Bacillarieae	-	present
Site #2			
Spirogyra fluviatilis	Chlorophyceae	dominant	-
Tabellaria sp.	Bacillarieae	common	-
Navicula gracilis	Bacillarieae	few	-
Fragilaria sp.	Bacillarieae	present	few
Oscillatoria limosa	Myxophyceae	-	few
Anabaena sp.	Myxophyceae	-	present
Surirella sp.	Bacillarieae	present	-
Gomphonema vibrio	Bacillarieae	present	present
Pinnularia viridis	Bacillarieae	-	present
Site #3			
Spirogyra fluviatilis	Chlorophyceae	dominant	-
Tabellaria sp.	Bacillarieae	common	-
Surirella sp.	Bacillarieae	few	present
Fragilaria sp.	Bacillarieae	few	-
Oscillatoria limosa	Myxophyceae	-	few
Anabaena sp.	Myxophyceae	-	present
Desmidium grevillii	Chlorophyceae	present	-
Ankistrodesmus falcatus	Chlorophyceae	-	present
Navicula gracilis	Bacillarieae	present	-
Pinnularia viridis	Bacillarieae	-	present
Site #4			
Fragilaria sp.	Bacillarieae	common	few
Pinnularia viridis	Bacillarieae	few	few
Surirella sp.	Bacillarieae	present	present
Tabellaria fenestrata	Bacillarieae	present	-
Closterium sp.	Chlorophyceae	-	present

(continued)

TABLE 6 (continued)

Species	Class	Occurrence 4/28/76	Occurrence 7/30/76
Site #5			
Fragilaria sp.	Bacillarieae	abundant	present
Diatoma elongatum	Bacillarieae	common	-
Surirella sp.	Bacillarieae	present	present
Navicula radiosa	Bacillarieae	present	-
Stauronesis sp.	Bacillarieae	-	present
Ankistrodesmus falcatus	Chlorophyceae	present	-
Oscillatoria limosa	Myxophyceae	-	present
Site #6			
Fragilaria sp.	Bacillarieae	abundant	-
Pinnularia viridis	Bacillarieae	common	present
Navicula gracilis	Bacillarieae	few	present
Tabellaria sp.	Bacillarieae	-	present
Cymbella lanceolata	Bacillarieae	present	-
Cosmarium bioculatum	Chlorophyceae	present	-
Trichodesmium lacustre	Myxophyceae	present	-
Batrachospermum sp.	Rhodophyceae	-	present
Site #8			
Oscillatoria limosa	Myxophyceae	abundant	few
Tabellaria sp.	Bacillarieae	common	present
Stauroneis sp.	Bacillarieae	few	present
Ankistrodesmus falcatus	Chlorophyceae	few	-
Fragilaria sp.	Bacillarieae	present	-
Anabaena sp.	Myxophyceae	-	present
Site #9			
Oscillatoria limosa	Myxophyceae	dominant	present
Navicula radiosa	Bacillarieae	common	-
Stauronesis sp.	Bacillarieae	-	few
Pinnularia viridis	Bacillarieae	present	present
Fragilaria sp.	Bacillarieae	present	-
Surirella sp.	Bacillarieae	-	present
Tabellaria sp.	Bacillarieae	-	present
Staurastrum limneticum	Chlorophyceae	present	-
Ankistrodesmus falcatus	Chlorophyceae	present	-

*Respective order of occurrence frequency — Most frequent to least frequent: dominant-abundant-common-few-present

TABLE 7. BIOLOGICAL OCCURRENCE OF STREAM BENTHOS UNDER LOW-FLOW CONDITIONS

Genus	Common Name	Occurrence		
		4/20/76	7/20/76	10/5/76
Site #1				
Eristalis	rat-tailed maggot, larva	dominant*	common	dominant
Ablabesmyia	midge larva	common	common	few
Gammarus	scud	-	-	common
Pisidium	pea shell clam	few	few	few
Physa	pouch snail	few	-	-
Sialis	alderfly larva	-	present	-
Cambarus	crayfish	-	present	-
Diemictylus	aquatic salamander	-	-	present
Site #2				
Gammarus	scud	dominant	few	dominant
Helocordulia	dragonfly nymph	-	abundant	-
Pisidium	pea shell clam	few	common	present
Diemictylus	aquatic salamander	few	-	few
Cambarus	crayfish	few	present	present
Baetis	mayfly nymph	present	present	-
Eristalis	rat-tailed maggot, larva	-	-	present
Site #3				
Gammarus	scud	dominant	few	dominant
Hagenius	dragonfly nymph	-	abundant	-
Baetis	mayfly nymph	few	-	present
Cambarus	crayfish	few	present	-
Diemictylus	aquatic salamander	few	-	-
Helocordulia	dragonfly nymph	-	few	few
Pisidium	pea shell clam	-	few	-
Ablabesmyia	midge larva	-	few	present
Physa	pouch snail	present	-	few
Site #4				
Baetis	mayfly nymph	abundant	-	common
Hagenius	dragonfly nymph	-	abundant	-
Acroneuria	stonefly nymph	common	-	few
Ablabesmyia	midge larva	present	common	few
Helocordulia	dragonfly nymph	few	common	common
Gammarus	scud	few	present	few

(continued)

TABLE 7 (continued)

Genus	Common Name	Occurrence		
		4/20/76	7/20/76	10/5/76
Pisidium	pea shell clam	few	few	present
Diemictylus	aquatic salamander	-	present	-
Site #5				
Gammarus	scud	dominant	present	dominant
Ablabesmyia	midge larva	few	abundant	present
Baetis	mayfly nymph	common	-	few
Pisidium	pea shell clam	few	few	present
Helocordulia	dragonfly nymph	-	few	few
Site #6				
Helocordulia	dragonfly nymph	abundant	common	few
Ablabesmyia	midge larva	abundant	few	present
Hagenius	dragonfly nymph	-	common	-
Gammarus	scud	present	few	common
Tabanus	larva	present	-	-
Pisidium	pea shell clam	-	-	present
Baetis	mayfly nymph	-	-	present
Site #8				
Helicopsyche	caddisfly larvae	abundant	common	common
Baetis	mayfly nymph	-	present	common
Helocordulia	dragonfly nymph	few	present	present
Ablabesmyia	midge larva	present	few	-
Pisidium	pea shell clam	-	-	present
Site #9				
Pisidium	pea shell clam	abundant	common	present
Acroneuria	stonefly nymph	few	common	common
Gammarus	scud	present	-	common
Helicopsyche	caddisfly larva	present	-	common
Cambarus	crayfish	few	present	-
Ablabesmyia	midge larva	present	few	present
Baetis	mayfly nymph	-	few	few

*Respective order of occurrence frequency — Most frequent to least frequent; dominant-abundant-common-few-present

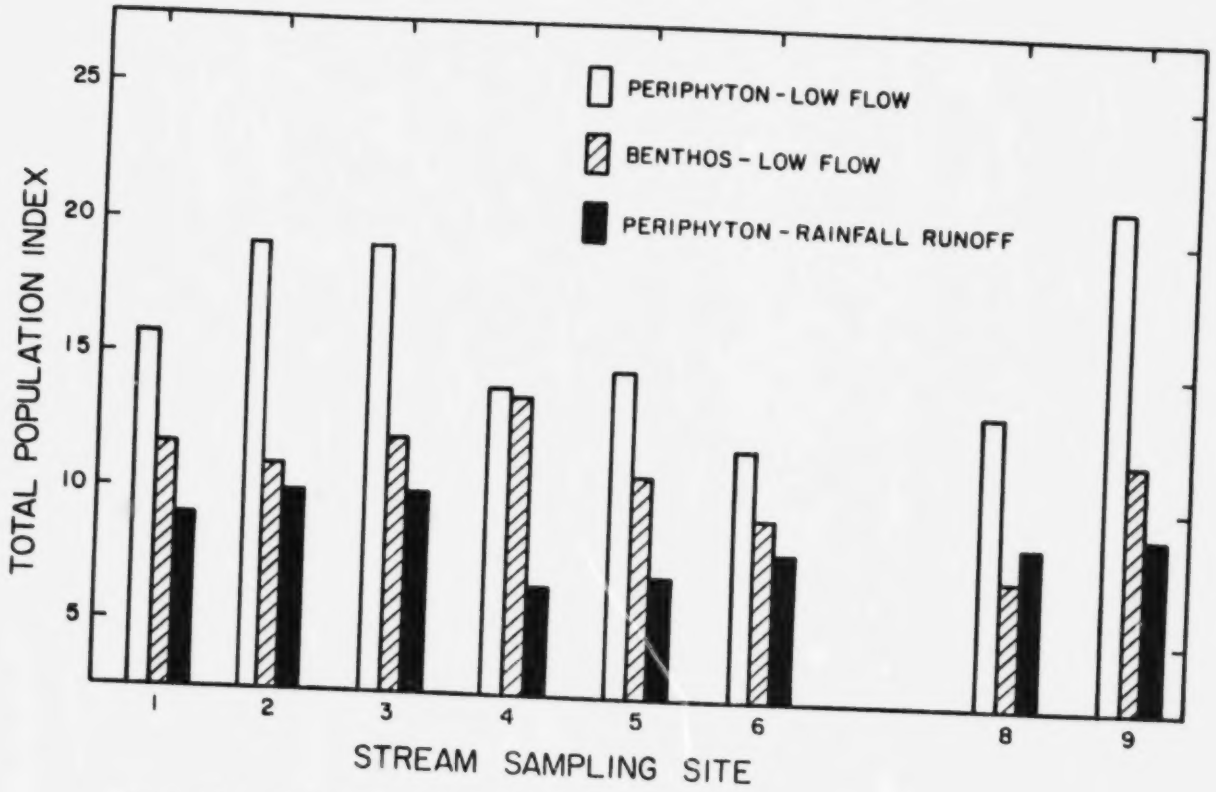

Figure 14. Total biological population index along receiving streams.

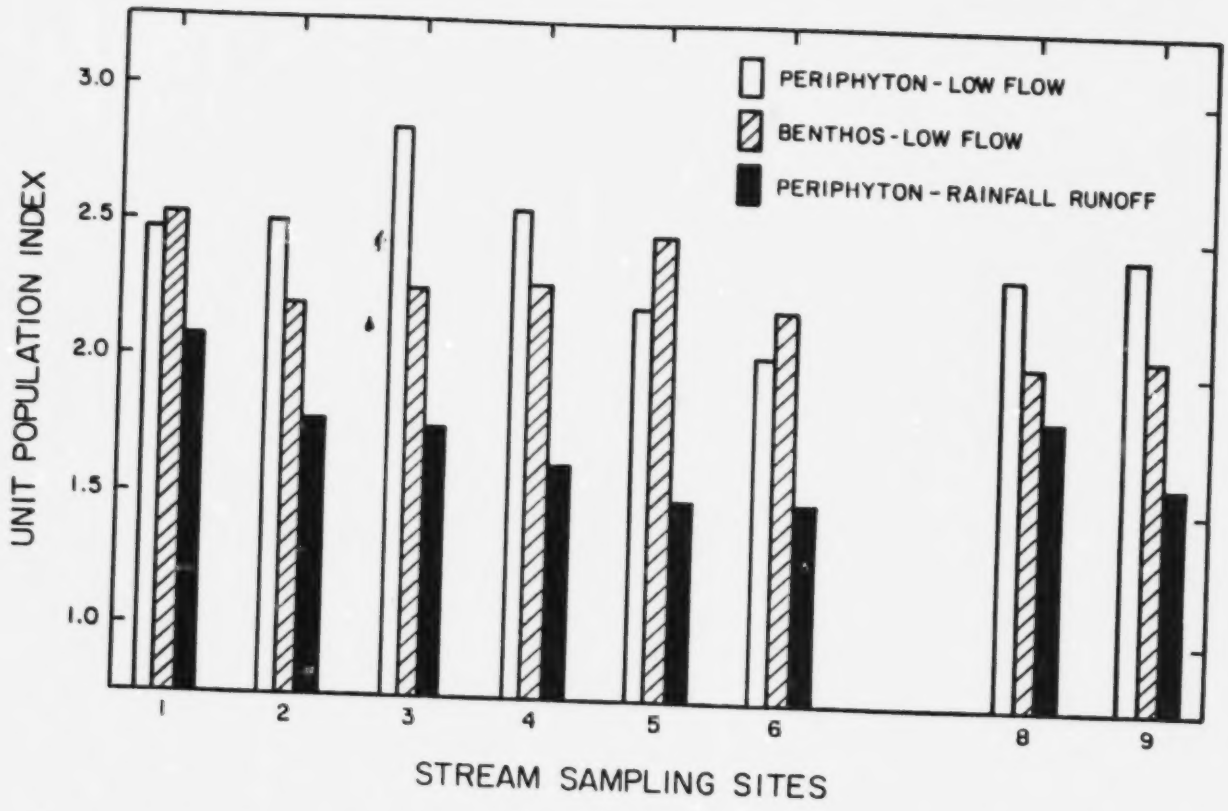

Figure 15. Unit biological population index along receiving streams.

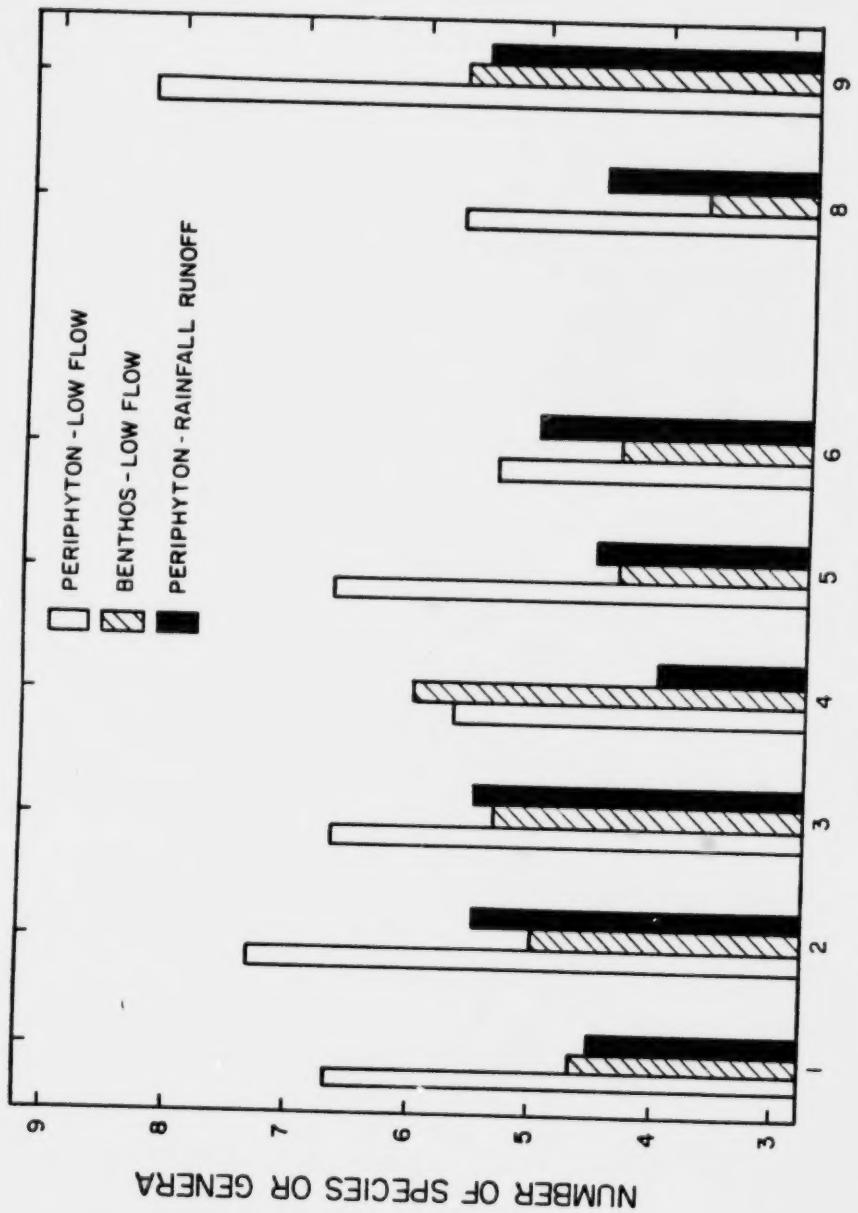

Figure 16. Number of species or genera identified along receiving streams.

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APPENDIX A

PHYSICAL AND CHEMICAL CONSTITUENT CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

TABLE A-1. RECEIVING STREAM FLOW RATES UNDER LOW-FLOW CONDITIONS

Sampling Date	Sampling Site			
	Headwaters 1	Background 2	Below Drylot 5	Recovery 6
	cfs			
11-5-75	0.062	0.132	0.234	0.294
11-17-75	0.058	0.127	0.233	0.225
12-10-75	0.116	0.256	0.469	0.453
2-10-76	0.154	0.401	0.761	0.682
2-18-76	0.121	0.263	0.721	0.545
2-28-76	0.127	0.195	0.558	0.600
3-13-76	0.182	0.251	0.812	0.895
3-27-76	0.070	0.235	0.456	0.492
4-10-76	0.086	0.145	0.340	0.419
4-24-76	0.122	0.338	0.495	0.586
5-8-76	0.078	0.118	0.407	0.308
5-22-76	0.035	0.045	0.173	0.165
6-5-76	0.071	0.075	0.251	0.451
6-26-76	0.021	0.047	0.076	0.091
7-10-76	0.089	0.097	0.459	0.424
7-24-76	0.083	0.039	0.392	0.529
8-7-76	0.080	0.151	0.384	0.419
8-28-76	0.095	0.191	0.276	0.305
9-11-76	0.055	0.122	0.216	0.223
9-25-76	0.048	0.105	0.196	0.183
10-9-76*	0.272	0.212	1.344	1.507
10-23-76	0.046	0.100	0.173	0.188
11-3-76	0.112	0.165	0.377	0.412
11-20-76	0.074	0.163	0.261	0.326
12-11-76	0.101	0.222	0.311	0.488
12-25-76	0.152	0.333	0.551	0.650
1-8-77	0.134	0.237	0.522	0.648
1-22-77	0.167	0.368	0.703	0.626
2-5-77	0.121	0.265	0.442	0.514
2-19-77	0.081	0.009	0.318	0.629
3-26-77	0.203	0.395	0.782	0.923
4-19-77	0.139	0.342	0.448	0.583
4-23-77	0.129	0.284	0.422	0.599
5-7-77	0.060	0.131	0.241	0.233
5-21-77	0.031	0.068	0.098	0.146
6-11-77	0.069	0.111	0.294	0.324
7-16-77	0.084	0.191	0.403	0.466
7-27-77	0.087	0.212	0.223	0.330
9-19-77	0.103	0.220	0.437	0.482
10-4-77	0.022	0.102	0.183	0.251
10-17-77	0.108	0.192	0.373	0.420
10-20-77	0.066	0.107	0.206	0.554
11-7-77*	0.307	1.004	1.899	1.605
12-5-77	0.161	0.768	0.649	0.873
1-6-78	0.260	0.587	1.062	0.722
4-26-78*	1.759	3.536	8.506	6.096
5-19-78*	0.229	0.804	1.200	1.160
2-26-79*	0.199	0.744	2.232	1.205
4-4-79*	0.566	0.767	2.123	1.718
Mean 43	0.099	0.207	0.404	0.458

*Not included in data summary

TABLE A-2. DISSOLVED OXYGEN CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling Date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	3.6	5.2	6.8	7.8	5.5	7.9
11-17-75	4.6	6.6	9.4	9.8	6.4	10.0
12-10-75	4.0	5.7	8.0	8.1	6.8	7.6
2-10-76	4.2	9.8	12.1	8.4	8.4	11.4
2-18-76	4.3	7.2	8.1	5.2	7.0	9.0
2-28-76	7.5	7.1	7.2	7.7	6.5	10.8
3-13-76	6.1	7.5	8.1	7.7	7.7	9.7
3-27-76	7.5	8.0	8.5	8.2	7.2	9.9
4-10-76	6.6	7.9	9.6	7.9	7.5	11.1
4-24-76	3.9	5.1	7.3	7.1	6.1	9.1
5-8-76	5.2	6.0	9.1	6.9	7.2	8.3
5-22-76	2.9	5.2	7.9	6.8	5.2	9.0
6-5-76	4.9	6.4	7.4	7.1	5.9	9.3
6-26-76	4.7	4.2	5.6	6.7	5.3	8.7
7-10-76	4.2	3.7	5.1	8.0	7.3	11.3
7-24-76	2.0	4.0	4.9	5.2	5.0	7.4
8-7-76	2.2	4.0	5.6	6.3	4.5	7.5
8-28-76	4.0	5.3	8.0	8.3	7.2	8.6
9-11-76	3.4	4.2	7.8	6.6	5.9	8.1
9-25-76	4.1	3.8	8.9	8.3	6.3	8.7
10-9-76	2.5	4.2	6.5	6.1	4.0	8.4
10-23-76	1.7	5.7	11.6	10.4	9.2	10.4
11-3-76	1.3	5.2	13.2	12.7	9.3	15.2
11-20-76	2.3	10.1	13.2	13.4	9.8	12.1
12-11-76	5.7	10.3	14.3	13.9	12.1	9.6
12-25-76	7.9	11.9	11.2	12.4	10.4	10.8
1-8-77	7.1	10.1	11.6	12.1	9.8	12.0
1-22-77	6.0	10.4	10.4	10.5	9.4	12.2
2-5-77	3.3	8.3	8.3	7.4	8.4	10.4
2-19-77	6.8	7.4	9.6	9.3	7.8	9.8
3-26-77	6.2	6.2	7.8	8.2	6.9	8.4
4-19-77	3.6	5.2	7.7	6.5	5.2	8.1
4-23-77	3.5	4.5	7.3	7.4	5.5	8.4
5-7-77	3.2	4.4	6.5	7.7	6.4	8.9
5-21-77	1.6	3.4	6.3	7.2	6.3	7.8
6-11-77	2.4	3.6	6.3	6.7	5.5	8.3
7-16-77	3.2	4.5	6.2	6.2	4.5	7.7
7-27-77	2.0	3.2	6.6	7.1	5.9	7.6
9-19-77	4.4	6.4	8.4	7.8	6.8	9.6
10-4-77	1.2	3.2	8.9	10.5	5.7	8.7
10-17-77	4.6	5.6	6.4	8.6	5.8	8.4
10-20-77	2.0	4.2	7.9	8.8	7.1	10.4
11-7-77	4.8	4.5	5.8	6.2	5.2	7.5
12-5-77	5.0	6.6	9.6	9.5	8.2	10.6
1-6-78	6.0	8.5	8.9	9.2	9.0	10.3
4-26-78	3.2	5.6	6.3	6.3	4.8	6.1
5-19-78	2.6	6.4	6.9	6.9	5.7	7.7
2-26-79	10.2	8.6	13.9	13.9	11.0	11.8
4-4-79	7.3	10.0	10.4	10.4	6.3	8.8
Mean						
49	4.32	6.23	8.45	8.40	6.96	9.38

TABLE A-3. CHEMICAL OXYGEN DEMAND OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	23.97	20.45	15.80	35.60	39.60	35.48
11-17-75	14.71	12.55	12.00	16.00	28.00	21.77
12-10-75	21.29	18.17	20.00	20.00	40.00	31.52
2-10-76	18.00	20.00	22.00	34.00	44.00	36.04
2-18-76	14.00	16.00	20.00	27.00	47.00	31.61
2-26-76	27.45	11.76	17.65	15.69	35.29	43.14
3-13-76	11.76	39.22	31.37	31.37	49.02	50.98
3-27-76	15.69	11.76	19.61	27.45	59.52	39.68
4-10-76	15.87	11.90	15.87	19.84	23.81	35.71
4-24-76	31.75	27.78	23.81	23.81	55.56	47.62
5-8-76	19.68	11.81	11.81	19.68	31.49	15.75
5-22-76	35.43	39.37	23.62	55.11	35.43	35.43
6-5-76	29.78	27.56	27.56	35.43	43.30	43.30
6-26-76	36.30	26.16	32.25	44.35	48.38	32.25
7-10-76	40.32	24.19	23.70	47.40	75.10	75.10
7-24-76	75.10	35.60	79.04	47.42	75.10	47.40
8-7-76	19.76	20.16	19.76	47.40	71.50	47.40
8-28-76	42.96	31.25	31.25	39.06	42.96	23.43
9-11-76	19.53	19.53	23.52	35.13	39.52	42.96
9-25-76	54.68	35.16	19.53	35.13	35.13	35.13
10-9-76	19.53	19.53	15.68	62.75	100.97	73.45
10-23-76	15.68	7.53	7.53	15.68	62.75	50.98
11-3-76	47.40	3.93	7.53	19.53	62.98	50.68
11-20-76	27.67	31.62	47.44	35.58	35.58	43.48
12-11-76	15.81	31.62	23.72	27.67	51.39	31.62
12-25-76	27.67	27.67	59.30	39.53	35.58	51.39
1-8-77	11.85	7.90	19.76	39.52	35.57	47.43
1-22-77	11.85	7.90	15.81	31.62	51.38	51.38
2-5-77	39.50	19.76	7.90	39.06	31.62	23.71
2-19-77	46.87	31.25	23.44	35.16	31.25	35.16
3-26-77	11.90	23.81	15.87	27.78	39.68	27.78
4-19-77	15.81	11.86	7.91	11.86	15.81	15.81
4-23-77	19.76	27.67	11.86	19.76	51.38	39.53
5-7-77	70.88	17.24	21.07	32.60	32.60	32.60
5-21-77	63.22	13.41	21.07	17.24	30.65	28.74
6-11-77	21.20	28.90	28.90	36.54	55.80	40.40
7-16-77	25.00	40.40	44.23	59.62	51.92	48.10
7-27-77	17.31	25.00	28.90	28.90	32.70	32.70
9-19-77	27.13	39.00	35.28	47.00	78.00	59.17
10-4-77	12.00	23.00	23.00	27.00	31.00	35.00
10-17-77	12.00	23.00	12.00	27.00	31.00	31.00
10-20-77	15.20	11.40	27.00	23.00	27.00	27.00
11-7-77	46.00	49.43	65.00	72.24	72.24	72.24
12-5-77	19.20	23.00	20.49	27.79	38.31	34.36
1-6-78	13.00	13.00	17.00	13.00	17.00	20.36
4-26-78	31.73	34.00	28.01	37.99	44.00	42.00
4-4-79	21.50	28.60	22.83	30.97	37.60	37.60
Mean 47	27.12	23.02	24.44	32.84	44.80	39.48

TABLE A-4. TOTAL KJELDAHL NITROGEN CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	0.49	0.40	0.30	0.62	0.59	0.60
11-17-75	0.52	0.43	0.53	0.47	0.49	0.63
12-10-75	0.48	0.40	0.17	0.44	0.98	0.59
2-10-76	0.45	0.53	0.38	0.90	1.50	0.90
2-18-76	1.01	0.60	0.68	0.50	1.64	1.09
2-26-76	4.20	2.45	1.34	1.95	3.90	4.28
3-13-76	2.54	1.83	1.49	2.18	3.90	3.56
3-27-76	1.65	2.25	3.74	4.91	3.39	2.30
4-10-76	4.35	1.89	2.03	2.51	5.01	6.20
4-24-76	3.30	4.97	2.19	6.05	3.36	3.53
5-8-76	0.58	0.34	0.75	1.00	2.08	1.14
5-22-76	1.63	1.00	0.49	0.85	0.99	1.25
6-5-76	1.25	0.64	0.60	1.35	1.85	2.27
6-26-76	0.74	0.54	0.63	0.75	0.68	0.81
7-10-76	1.05	0.45	0.60	1.11	1.17	1.22
7-24-76	1.55	1.08	0.93	1.83	2.10	2.10
8-7-76	1.28	1.13	0.90	1.13	1.49	1.70
8-28-76	1.86	1.35	1.32	1.58	1.08	1.50
9-11-76	1.20	0.86	0.95	1.58	1.83	1.94
9-25-76	2.03	0.81	1.28	1.80	1.85	2.06
10-9-76	0.68	1.25	0.98	1.50	5.55	2.48
10-23-76	1.13	0.93	1.04	1.13	0.92	0.96
11-3-76	1.35	1.10	0.78	0.60	1.04	0.75
11-20-76	0.84	0.50	0.72	0.72	0.72	0.60
12-11-76	1.41	1.07	0.59	0.87	0.83	0.93
12-25-76	0.87	0.93	0.90	1.61	1.35	1.05
1-8-77	0.75	1.61	1.28	2.10	2.00	1.38
1-22-77	1.16	1.16	0.60	1.14	1.73	1.56
2-5-77	1.47	1.05	1.20	1.65	1.88	1.95
2-19-77	1.83	1.35	1.35	2.07	1.68	0.69
3-26-77	2.15	1.40	1.80	2.10	2.93	3.00
4-19-77	0.50	0.36	0.53	1.01	0.93	0.90
4-23-77	0.71	0.39	0.42	1.53	1.01	0.57
5-7-77	1.50	1.58	0.95	1.40	0.57	1.28
5-21-77	1.68	0.48	0.90	0.69	1.10	0.65
6-11-77	0.75	1.35	1.05	1.80	1.95	1.59
7-16-77	1.35	1.20	1.65	1.35	2.07	1.89
7-27-77	1.50	1.20	1.26	0.99	0.90	1.65
9-19-77	1.47	1.41	1.14	1.41	1.95	1.86
10-4-77	1.35	1.26	1.47	1.65	1.71	1.14
10-17-77	1.47	1.20	1.05	1.14	1.47	1.35
10-20-77	1.50	1.11	1.20	1.11	1.38	1.05
11-7-77	0.75	0.96	1.59	1.41	1.47	1.50
12-5-77	0.60	0.87	0.60	0.84	0.90	0.97
1-6-78	0.96	0.90	0.87	0.87	0.66	1.12
4-26-78	1.67	1.35	1.25	1.75	2.09	2.01
4-4-79	0.60	0.39	0.34	0.48	0.51	0.42
Mean						
47	1.37	1.11	1.04	1.46	1.73	1.60

TABLE A-5. NITRATE NITROGEN CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling Date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	0.30	0.06	0	0	0.10	0.10
11-17-75	0.30	0.06	0	0	0.10	0.10
12-10-75	0.78	0.15	0.10	0.05	0	0.25
2-10-76	2.84	1.36	0.53	0.40	0.32	1.29
2-18-76	2.30	0.70	0.20	0.20	0.10	0.64
2-26-76	2.00	0.40	0.10	0	0	0
3-13-76	1.50	0.10	0	0	0	0
3-27-76	1.40	0.10	0	0	0	0
4-10-76	1.60	0.10	0	0	0	0
4-24-76	1.30	0.10	0	0	0	0.10
5-8-76	1.40	0	0	0	0	0.10
5-22-76	1.20	0	0	0	0	0.10
6-5-76	0.60	0	0	0	0.14	0.21
6-26-76	1.42	0.01	0.02	0.07	0.12	0.19
7-10-76	0.98	0.02	0.01	0.04	1.69	1.56
7-24-76	0.85	0.02	0.01	1.24	0.15	0.14
8-7-76	0.97	0.01	0.01	0.06	0.05	0.05
8-28-76	0.70	0.02	0.02	0.05	0.59	0.49
9-11-76	0.29	0.01	0.01	0.42	0.12	0.14
9-25-76	0.27	0	0.02	0.05	2.60	2.00
10-9-76	0.23	0.02	0.02	1.60	0.11	0.22
10-23-76	0.34	0	0.01	0.21	0.05	0.03
11-3-76	0.49	0	0.01	0.03	0.35	0.30
11-20-76	0.60	0.03	0.01	0.06	0.57	0.51
12-11-76	1.56	0.02	0.05	0.15	0.73	0.70
12-25-76	2.20	0.34	0.15	0.20	2.00	1.90
1-8-77	2.00	0.66	0.25	0.41	1.15	1.03
1-22-77	2.80	1.30	0.74	0.65	0.98	0.95
2-5-77	2.30	2.00	0.58	0.58	0.82	0.56
2-19-77	2.30	0.87	0.47	0.44	1.03	0.92
3-26-77	2.70	0.83	0.58	0.51	0.38	0.34
4-19-77	1.90	0.22	0.09	0.15	0.26	0.26
4-23-77	1.40	0.03	0.04	0.10	0.13	0.13
5-7-77	1.79	0.03	0.04	0.08	0.08	0.09
5-21-77	2.01	0.02	0.03	0.05	0.37	0.39
6-11-77	1.43	0.04	0.04	0.32	0.36	0.37
7-16-77	1.10	0.01	0.04	0.33	0.03	0.06
7-27-77	1.51	0	0.02	0.04	0.07	0.15
9-19-77	1.32	0.01	0.04	0.04	0.06	0.02
10-4-77	1.30	0	0	0.02	0.37	0.36
10-17-77	1.64	0.02	0.01	0.32	0.21	0.17
10-20-77	1.57	0.04	0.02	0.21	0.55	0.46
11-7-77	1.04	0.12	0.04	0.56	1.29	0.68
12-5-77	1.51	0.17	0.17	0.36	2.00	2.03
1-6-78	2.70	1.07	0.72	1.38	1.20	1.10
4-26-78	4.33	1.14	0.34	0.74	1.62	2.48
4-4-79	1.70	0.40	0.32	0.70		
Mean 47	1.46	0.27	0.12	0.27	0.49	0.50

TABLE A-6. TOTAL PHOSPHORUS CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling Date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	0.07	0.04	0.05	0.11	0.17	0.21
11-17-75	0.04	0.02	0.04	0.04	0.11	0.12
12-10-75	0.06	0.04	0.05	0.08	0.18	0.19
2-10-76	0.02	0.02	0.02	0.16	0.77	0.27
2-18-76	0.05	0.04	0.04	0.04	0.62	0.24
2-28-76	0.10	0.09	0.06	0.12	0.46	0.44
3-13-76	0.07	0.06	0.08	0.13	0.53	0.51
3-27-76	0.07	0.06	0.09	0.12	0.47	0.43
4-10-76	0.10	0.07	0.10	0.13	0.36	0.35
4-24-76	0.12	0.12	0.09	0.15	0.46	0.41
5-8-76	0.07	0.07	0.08	0.13	0.53	0.45
5-22-76	0.17	0.07	0.07	0.12	0.34	0.30
6-5-76	0.12	0.06	0.05	0.13	0.41	0.64
6-26-76	0.11	0.04	0.04	0.12	0.24	0.35
7-10-76	0.15	0.05	0.03	0.19	0.88	0.78
7-24-76	0.43	0.06	0.08	0.19	0.52	0.52
8-7-76	0.11	0.05	0.07	0.22	0.38	0.44
8-28-76	0.05	0.05	0.04	0.09	0.14	0.14
9-11-76	0.08	0.06	0.06	0.15	0.26	0.22
9-25-76	0.33	0.06	0.07	0.22	0.47	0.49
10-9-76	0.09	0.06	0.14	0.23	1.35	0.71
10-23-76	0.10	0.05	0.05	0.32	0.13	0.30
11-3-76	0.30	0.07	0.06	0.13	0.35	0.28
11-20-76	0.13	0.11	0.11	0.20	0.49	0.39
12-11-76	0.12	0.13	0.11	0.19	0.41	0.35
12-25-76	0.09	0.09	0.13	0.26	0.38	0.41
1-8-77	0.08	0.09	0.09	0.33	0.51	0.47
1-22-77	0.09	0.08	0.11	0.28	0.43	0.39
2-5-77	0.10	0.09	0.11	0.24	0.36	0.39
2-19-77	0.21	0.11	0.19	0.38	0.45	0.26
3-26-77	0.17	0.15	0.17	0.35	0.56	0.67
4-19-77	0.12	0.07	0.11	0.24	0.53	0.43
4-23-77	0.11	0.08	0.14	0.38	0.54	0.59
5-7-77	0.21	0.04	0.05	0.11	0.21	0.57
5-21-77	0.17	0.02	0.03	0.08	0.09	0.13
6-11-77	0.04	0.04	0.08	0.19	0.35	0.32
7-16-77	0.08	0.05	0.15	0.26	0.34	0.30
7-27-77	0.11	0.08	0.10	0.15	0.15	0.23
9-19-77	0.15	0.08	0.09	0.17	0.42	0.41
10-4-77	0.04	0.05	0.04	0.13	0.20	0.19
10-17-77	0.23	0.10	0.11	0.19	0.34	0.30
10-20-77	0.17	0.15	0.09	0.19	0.34	0.27
11-7-77	0.11	0.08	0.20	0.26	0.45	0.41
12-5-77	0.11	0.08	0.08	0.17	0.34	0.36
1-6-78	0.11	0.13	0.13	0.15	0.23	0.43
4-26-78	0.16	0.11	0.11	0.23	0.49	0.44
4-4-79	0.19	0.15	0.11	0.23	0.30	0.30
Mean 47	0.13	0.07	0.09	0.18	0.41	0.38

TABLE A-7. CHLORIDES CONCENTRATIONS OF RECEIVING STREAM UNDER LOW-FLOW CONDITIONS

Sampling Date	Sampling Site					
	Headwaters 1	Background 2	Background 3	At Drylot 4	Below Drylot 5	Recovery 6
	mg/l					
11-5-75	6.6	5.3	5.4	5.4	5.2	6.3
11-17-75	6.9	5.6	5.4	5.6	5.8	6.6
12-10-76	6.1	4.9	4.8	5.0	5.0	5.8
2-10-76	9.6	6.3	6.6	5.5	6.6	7.8
2-18-76	12.1	8.5	6.4	5.6	7.0	8.8
2-26-76	8.7	6.0	4.7	5.4	4.8	5.1
3-13-76	6.4	5.2	4.3	3.3	4.7	4.9
3-27-76	6.1	4.4	3.6	2.7	5.0	5.1
4-10-76	6.6	4.4	4.8	5.1	4.9	4.7
4-26-76	7.4	6.5	5.3	5.0	5.3	5.5
5-8-76	7.4	6.0	4.5	5.2	4.2	2.9
5-22-76	6.6	4.4	3.8	4.1	5.0	4.7
6-5-76	6.5	5.0	5.1	5.0	6.1	8.6
6-26-76	8.1	6.0	5.1	5.1	6.0	6.2
7-10-76	7.3	5.6	5.5	7.5	8.5	8.9
7-24-76	8.1	6.5	5.6	8.6	12.6	11.0
8-7-76	7.9	6.0	5.5	6.0	8.4	6.0
8-28-76	6.9	7.3	6.1	4.3	6.4	6.9
9-11-76	9.0	7.9	6.7	6.3	8.4	8.0
9-25-76	8.5	6.5	5.8	5.3	9.3	8.3
10-9-76	7.0	5.5	5.7	8.0	11.0	11.3
10-23-76	6.7	6.2	6.3	9.0	7.5	8.3
11-3-76	7.5	5.5	5.0	6.0	7.9	7.7
11-20-76	6.9	6.0	5.1	6.6	8.9	12.9
12-11-76	7.6	7.0	5.4	7.9	9.0	8.9
12-25-76	6.6	5.5	5.4	5.5	7.3	7.3
1-8-77	6.2	7.2	5.3	6.5	8.5	8.6
1-22-77	6.4	5.5	6.5	5.7	7.6	7.2
2-5-77	6.3	5.5	5.0	6.0	7.8	7.6
2-19-77	6.3	5.5	5.0	5.5	8.0	7.0
3-26-77	7.0	4.6	3.8	4.5	2.6	2.7
4-19-77	6.0	5.0	4.5	4.4	6.0	5.2
4-23-77	6.4	5.6	4.7	5.5	6.2	6.4
5-7-77	8.1	6.0	5.2	5.1	5.9	5.5
5-21-77	8.0	7.0	5.4	5.4	5.7	5.6
6-11-77	9.2	6.2	5.4	7.0	9.0	8.6
7-16-77	7.5	6.8	6.8	7.9	8.7	8.5
7-27-77	8.0	7.3	5.0	5.7	4.8	5.8
9-19-77	7.5	6.5	5.8	6.4	8.5	7.8
10-4-77	7.0	6.5	5.2	5.6	6.9	6.2
10-17-77	7.1	6.0	5.3	7.1	9.5	9.5
10-20-77	6.9	6.0	5.0	6.5	8.4	8.2
11-7-77	6.9	4.5	5.9	4.0	5.2	6.5
12-5-77	6.4	5.5	5.5	6.0	9.3	7.3
1-6-78	6.6	5.3	4.9	6.7	8.5	7.2
4-26-78	5.0	4.0	3.6	3.9	4.8	4.8
4-4-79	6.0	5.5	5.3	5.8	8.0	7.8
Mean 47	7.23	5.87	5.26	5.75	7.04	7.07

APPENDIX B

INDIVIDUAL RAINFALL RUNOFF EVENT CHEMICAL CONSTITUENT STATISTICS OF RECEIVING STREAM DURING STUDY PERIOD

TABLE B-1. INDIVIDUAL RAINFALL RUNOFF EVENT CHEMICAL OXYGEN DEMAND STATISTICS OF RECEIVING STREAM HEADWATERS(SITE 1) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		----------mg/l----------				%
5-8-76	27	15.03	3.96	7.84	23.53	26.35
5-29-76	27	11.82	4.40	7.75	19.53	37.26
6-5-76	27	12.59	4.78	7.91	23.71	37.96
7-5-76	26	33.33	12.74	8.03	59.76	38.22
7-31-76	12	25.89	10.54	7.96	43.80	40.69
8-7-76	27	23.69	8.01	8.03	40.16	33.80
8-14-76	27	31.31	12.48	11.72	54.68	39.85
10-9-76	26	25.22	15.17	7.84	74.51	60.15
10-16-76	26	29.67	15.04	7.84	71.14	50.67
10-23-76	27	16.93	14.97	3.90	62.75	88.42
10-28-76	27	20.34	9.84	3.92	39.22	48.40
11-7-76	27	18.66	8.79	3.92	35.29	47.11
11-13-76	27	23.70	12.48	3.92	59.05	52.64
11-27-76	27	35.06	20.54	7.94	98.81	58.58
12-11-76	27	46.42	22.58	7.94	95.24	48.65
2-19-77	19	13.10	3.74	7.90	19.75	28.55
4-30-77	27	35.43	27.29	10.00	108.00	77.00
5-28-77	27	40.72	11.15	22.97	67.41	27.38
6-25-77	27	25.16	14.68	10.00	66.10	58.34
7-3-77	27	36.48	20.81	12.00	180.64	57.04
8-16-77	27	23.14	3.57	12.00	32.69	15.44
8-30-77	26	50.94	15.91	31.00	96.00	31.23
9-13-77	26	61.98	21.30	39.00	131.00	34.36
9-19-77	26	23.98	11.00	8.00	54.30	45.88
10-17-77	26	29.10	5.70	23.00	38.31	19.60
10-27-77	26	27.65	5.97	23.00	42.00	21.58
11-10-77	27	35.63	5.92	23.00	46.00	16.60
12-6-77	27	15.58	4.63	4.00	23.00	29.72
12-30-77	26	16.42	5.11	4.00	23.00	31.11
1-4-78	27	17.77	1.92	15.00	21.00	10.81
1-11-78	26	13.69	4.97	8.00	21.00	36.32
1-17-78	25	19.67	4.12	15.00	29.00	20.95
1-23-78	27	19.14	5.30	12.00	29.00	27.71
1-26-78	27	30.29	13.96	17.00	56.00	46.10
3-13-78	27	21.93	9.60	10.00	40.16	43.75
4-18-78	27	29.07	5.42	15.00	40.16	18.66
4-26-78	27	23.32	7.43	11.72	38.00	31.87
7-25-78	27	38.74	9.19	21.00	59.05	23.72
9-11-78	27	25.56	3.96	15.00	33.00	15.50
	No. of events	Mean		Min.	Max.	
Study Period	39	26.77		3.90	180.54	

TABLE B-2. INDIVIDUAL RAINFALL RUNOFF EVENT CHEMICAL OXYGEN DEMAND STATISTICS OF RECEIVING STREAM BACKGROUND REACH (SITE 2) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		mg/l				%
5-18-76	17	24.32	4.28	15.80	31.50	17.58
8-7-76	27	51.72	9.84	33.68	77.28	19.03
1-1-77	27	70.84	22.82	31.01	108.00	32.21
4-30-77	25	59.42	35.19	17.34	152.22	59.22
5-28-77	27	64.66	30.48	32.69	166.03	47.14
6-25-77	17	46.10	19.77	26.82	99.62	42.89
8-16-77	10	42.40	4.81	35.00	49.00	11.35
8-30-77	26	63.81	22.64	42.20	138.00	35.47
9-13-77	25	75.35	19.38	54.00	117.31	25.72
9-19-77	26	78.40	22.58	50.40	132.00	28.80
10-17-77	26	66.67	20.02	46.00	100.00	30.02
11-7-77	25	46.42	3.33	42.00	53.23	7.18
11-10-77	27	45.17	5.10	38.31	58.00	11.30
12-6-77	14	26.43	2.76	23.00	31.00	10.44
12-15-77	12	38.83	16.22	12.00	55.00	41.76
12-22-77	26	30.23	6.17	23.00	46.00	20.40
1-4-78	26	27.69	7.17	15.00	40.00	25.89
1-17-78	26	23.00	4.90	15.00	29.00	21.30
1-23-78	27	23.71	7.93	10.00	31.00	33.44
1-26-78	27	33.00	9.80	21.00	45.00	29.69
3-13-78	24	37.00	5.51	31.01	47.00	14.90
4-18-78	23	55.67	4.27	48.00	60.00	7.68
4-26-78	19	40.78	6.84	33.00	48.50	16.78
7-25-78	23	83.73	18.21	66.10	119.10	21.75
9-11-78	23	51.67	7.38	41.70	61.00	14.29
	No. of events	Mean		Min.	Max.	
Study Period	25	48.28		10.00	166.03	

TABLE B-3. INDIVIDUAL RAINFALL RUNOFF EVENT CHEMICAL OXYGEN DEMAND STATISTICS OF RECEIVING STREAM BELOW DRYLOT(SITE 5) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
			mg/l			%
5-8-76	17	58.52	12.40	41.50	94.86	21.19
5-22-76	6	61.73	2.36	58.14	63.24	3.83
8-7-76	27	101.86	61.16	43.82	338.60	60.04
1-1-77	27	117.90	47.41	51.38	222.65	40.21
4-30-77	26	117.25	79.63	59.16	362.23	67.91
5-28-77	27	128.25	22.37	90.86	178.85	17.44
6-7-77	24	103.86	40.74	65.13	229.90	39.22
7-3-77	25	111.28	58.26	61.30	272.03	52.35
9-13-77	25	104.02	27.38	77.00	192.31	26.32
9-19-77	27	59.20	6.86	50.40	78.00	11.59
10-17-77	24	99.78	30.23	77.00	176.30	30.30
10-27-77	26	48.03	12.09	34.10	80.00	25.17
11-7-77	27	45.92	10.88	38.31	81.00	23.70
11-10-77	27	82.75	13.82	65.13	107.30	16.71
11-28-77	26	44.03	7.78	35.00	61.30	17.68
12-6-77	25	50.17	6.88	38.31	59.40	13.72
12-15-77	26	164.54	149.01	63.00	577.00	90.56
12-22-77	22	74.54	15.72	58.00	108.00	21.09
12-30-77	17	47.25	8.68	38.00	62.00	18.37
1-4-78	25	50.33	7.61	42.00	67.00	15.12
1-11-78	23	53.54	16.14	33.00	95.00	30.15
1-17-78	26	56.00	22.95	33.00	104.00	40.98
1-23-78	23	32.33	3.93	29.00	37.00	12.16
1-26-78	23	53.17	14.39	37.00	76.00	27.06
3-13-78	20	72.20	42.27	47.00	147.30	58.54
4-18-78	23	84.67	21.49	64.00	122.00	25.38
4-26-78	27	74.41	27.39	52.40	133.20	36.80
7-25-78	23	96.95	13.61	77.80	116.70	14.04
9-11-78	23	69.92	6.83	64.40	82.40	9.77
	No. of events	Mean		Min.	Max.	
Study Period	29	78.08		29.00	577.00	

TABLE B-4. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL KJELDAHL NITROGEN CONCENTRATION STATISTICS OF RECEIVING STREAM HEADWATERS (SITE 1) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		mg/l				%
5-8-76	27	0.57	0.14	0.30	0.87	24.16
5-29-76	27	0.92	0.39	0.30	1.71	42.16
6-5-76	26	1.31	0.28	0.91	2.16	21.60
7-5-76	26	1.72	0.30	1.13	2.40	17.68
7-31-76	12	1.47	0.52	1.01	2.78	34.95
8-7-76	27	1.37	0.25	0.96	2.07	18.58
8-14-76	27	0.68	0.31	0.26	1.52	45.89
10-9-76	26	0.72	0.30	0.21	1.55	41.11
10-16-76	26	1.02	0.41	0.50	1.88	40.42
10-23-76	27	0.98	0.25	0.60	1.49	25.34
10-28-76	27	0.78	0.18	0.53	1.20	23.89
11-7-76	27	0.67	0.28	0.24	1.28	41.50
11-13-76	27	0.57	0.26	0.15	1.20	44.48
11-27-76	27	0.54	0.20	0.24	0.95	37.50
12-11-76	26	0.50	0.22	0.24	0.96	44.71
2-19-77	19	1.01	0.30	0.57	1.64	29.93
4-30-77	27	1.33	0.37	0.77	2.29	27.94
5-23-77	27	1.55	0.24	1.11	2.11	15.44
6-25-77	27	0.76	0.27	0.46	1.40	35.03
7-3-77	27	1.78	1.04	0.57	4.59	58.08
8-16-77	27	0.86	0.26	0.58	1.53	30.81
8-30-77	26	1.45	0.89	0.72	3.96	61.37
9-13-77	26	1.18	0.84	0.36	3.96	71.48
9-19-77	26	1.58	0.25	1.17	2.25	15.78
10-17-77	26	1.48	0.21	1.05	1.95	14.10
10-27-77	26	1.58	0.36	0.84	2.55	22.88
11-10-77	27	1.26	0.18	0.90	1.56	14.56
12-6-77	27	1.01	0.24	0.60	1.68	24.21
12-30-77	26	1.46	0.31	0.90	1.95	20.93
1-4-78	27	1.24	0.29	0.75	1.74	23.77
1-11-78	26	0.64	0.13	0.45	0.90	20.72
1-17-78	25	1.12	0.15	0.81	1.38	13.47
1-23-78	27	0.85	0.15	0.75	1.17	17.88
1-26-78	27	2.58	0.65	1.95	3.60	25.31
3-13-78	27	0.87	0.24	0.63	1.27	28.23
4-18-78	27	0.87	0.20	0.65	1.19	22.65
4-26-78	27	1.23	0.17	1.03	1.56	14.09
7-25-78	27	1.44	0.31	1.05	1.91	21.37
9-11-78	27	0.90	0.26	0.58	1.26	28.95
	No. of events	Mean		Min.	Max.	
Study Period	39	1.12		0.15	4.59	

TABLE B-5. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL KJELDAHL NITROGEN CONCENTRATION STATISTICS OF RECEIVING STREAM BACKGROUND REACH (SITE 2) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		mg/l				%
5-18-76	16	0.88	0.26	0.56	1.69	30.18
8-7-76	27	2.45	0.43	1.82	4.12	17.54
1-1-77	27	2.34	0.65	1.46	4.17	27.71
4-30-77	25	1.04	0.30	0.60	1.56	28.88
5-28-77	27	1.66	0.95	0.60	4.88	57.29
6-25-77	16	0.94	0.30	0.60	1.56	31.64
8-16-77	10	1.06	0.30	0.75	1.71	27.88
8-30-77	26	1.36	0.40	0.45	2.10	29.89
9-13-77	25	1.12	0.60	0.45	2.22	53.67
9-19-77	26	2.32	0.66	1.56	3.90	28.64
10-17-77	26	1.60	0.13	1.47	1.77	8.28
11-7-77	25	0.86	0.17	0.45	1.24	19.34
11-10-77	27	1.28	0.30	0.66	2.04	23.84
12-6-77	14	0.92	0.24	0.45	1.26	26.72
12-15-77	12	1.03	0.33	0.45	1.65	31.77
12-22-77	26	1.92	0.30	1.35	2.46	15.54
1-4-78	26	1.67	0.29	1.05	2.22	17.47
1-17-78	26	0.95	0.23	0.45	1.50	24.04
1-23-78	27	0.83	0.23	0.60	1.20	27.54
1-26-78	27	2.26	0.38	1.80	2.70	16.98
3-13-78	24	1.18	0.19	0.90	1.35	15.81
4-18-78	23	1.30	0.32	0.90	1.80	24.93
4-26-78	23	1.77	0.27	1.44	2.25	15.42
7-25-78	23	2.34	0.54	1.65	3.06	22.92
9-11-78	23	1.38	0.45	0.75	1.95	32.71
	No. of Events	Mean		Min.	Max.	
Study Period	25	1.46		0.45	4.88	

TABLE B-6. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL KJELDAHL NITROGEN CONCENTRATION STATISTICS OF RECEIVING STREAM BELOW DRYLOT (SITE 5) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		mg/l				%
5-8-76	17	2.71	0.50	1.80	3.73	18.46
5-22-76	6	2.44	0.65	1.86	3.63	26.74
8-7-76	27	5.98	4.41	1.80	21.01	73.64
1-1-77	27	4.47	1.79	2.48	10.13	40.00
4-30-77	26	4.28	1.45	2.35	8.64	33.94
5-28-77	27	4.08	1.48	1.95	7.05	36.19
6-7-77	24	2.95	0.97	0.93	4.65	32.78
7-3-77	25	4.20	3.18	1.26	12.45	75.69
9-13-77	25	3.90	2.06	1.80	9.00	52.85
9-19-77	27	1.38	0.42	0.75	2.37	30.66
10-17-77	24	2.35	0.80	1.35	4.41	34.22
10-27-77	26	2.03	0.57	1.05	3.27	28.06
11-7-77	27	1.23	0.20	0.81	1.65	16.41
11-10-77	27	1.74	0.36	1.20	3.00	20.55
11-28-77	26	1.60	0.64	0.75	3.06	40.11
12-6-77	25	1.32	0.29	0.96	2.07	22.01
12-15-77	25	4.35	2.64	1.80	12.15	60.78
12-22-77	26	3.09	1.26	1.47	6.00	40.56
12-30-77	17	2.20	0.39	1.56	2.82	17.81
1-4-78	26	1.93	0.32	1.41	2.52	16.50
1-11-78	24	1.78	0.39	1.20	2.46	21.75
1-17-78	26	1.76	0.32	1.05	2.46	18.12
1-23-78	23	1.14	0.18	0.96	1.38	15.49
1-26-78	23	2.98	0.42	2.37	3.60	14.17
3-13-78	20	1.84	0.99	1.26	3.60	53.64
4-18-78	23	1.64	0.32	1.35	2.07	19.69
4-26-78	27	2.41	0.31	2.07	3.00	13.02
7-25-78	23	2.33	0.42	1.80	2.91	17.84
9-11-78	23	1.64	0.37	1.26	2.10	22.44
	No. of events	Mean		Min.	Max.	
Study Period	29	2.61		0.75	21.01	

TABLE B-7. INDIVIDUAL RAINFALL RUNOFF EVENT NITRATE NITROGEN STATISTICS OF RECEIVING STREAM HEADWATERS (SITE 1) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		----------mg/l----------				%
5-8-76	27	1.76	0.06	1.65	1.85	3.19
5-29-76	27	1.73	0.18	1.30	2.40	10.61
6-5-76	27	1.58	0.21	1.30	1.90	13.06
7-5-76	26	1.12	0.19	0.48	1.38	16.92
7-31-76	12	0.90	0.05	0.82	0.96	5.81
8-7-76	27	0.99	0.06	0.89	1.12	5.89
8-14-76	25	0.95	0.08	0.78	1.09	8.96
10-9-76	26	0.35	0.03	0.28	0.42	9.60
10-16-76	25	0.19	0.03	0.07	0.23	14.50
10-23-76	27	0.39	0.06	0.27	0.51	14.45
10-28-76	27	0.52	0.10	0.37	0.74	18.31
11-7-76	26	0.41	0.09	0.25	0.54	21.68
11-13-76	27	0.45	0.06	0.34	0.56	12.49
11-27-76	27	0.59	0.04	0.49	0.64	6.22
12-11-76	27	0.48	0.13	0.11	0.66	25.98
2-19-77	19	3.34	0.21	2.90	3.70	6.25
4-30-77	27	0.80	0.06	0.69	0.86	7.74
5-28-77	27	1.82	0.14	1.55	2.13	7.78
6-25-77	27	0.17	0.08	0.06	0.35	46.39
7-3-77	27	0.82	0.10	0.49	0.95	12.64
8-16-77	27	0.01	0.01	0	0.03	64.29
8-30-77	25	0.37	0.07	0.26	0.45	19.23
9-13-77	26	0.50	0.10	0.25	0.69	19.15
9-19-77	26	1.83	0.08	1.62	1.93	4.54
10-17-77	26	0.93	0.12	0.76	1.12	12.56
10-27-77	26	0.85	0.12	0.66	1.05	14.40
11-10-77	27	2.05	0.03	1.91	2.08	1.68
12-6-77	27	1.66	0.05	1.57	1.76	2.92
12-30-77	26	2.86	0.17	2.50	3.07	5.97
1-4-78	27	2.87	0.31	2.42	3.50	10.86
1-11-78	26	2.86	0.10	2.65	3.01	3.42
1-17-78	25	2.79	0.16	2.47	3.10	5.80
1-23-78	27	3.03	0.13	2.79	3.15	4.36
1-26-78	27	2.47	0.67	1.38	3.17	27.34
3-13-78	27	3.02	0.25	2.71	3.20	8.21
4-18-78	27	1.54	0.14	1.34	1.60	9.11
4-26-78	27	2.03	0.07	2.02	2.08	3.39
7-25-78	27	1.83	0.17	1.60	1.96	9.27
9-11-78	27	0.36	0.09	0.23	0.57	25.48
	No. of events	Mean		Min.	Max.	
Study Period	39	1.36		0	3.70	

TABLE B-8. INDIVIDUAL RAINFALL RUNOFF EVENT NITRATE NITROGEN CONCENTRATION STATISTICS OF RECEIVING STREAM BACKGROUND REACH (SITE 2) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		mg/l				%
5-18-76	16	0.10	0.11	0.03	0.30	114.56
8-7-76	27	0.41	0.12	0.29	0.64	27.17
1-1-77	27	0.41	0.07	0.37	0.66	17.69
4-30-77	25	0.02	0.01	0	0.05	89.64
5-28-77	27	0.14	0.09	0	0.29	65.93
6-25-77	17	0.06	0.04	0.02	0.13	71.34
8-16-77	11	0.01	0.01	0	0.01	114.89
8-30-77	26	0.02	0.01	0	0.04	56.02
9-13-77	25	0.01	0.01	0	0.02	69.39
9-19-77	26	0.02	0.01	0	0.05	55.37
10-17-77	26	0.04	0.02	0.03	0.08	41.57
11-7-77	25	0.01	0.01	0	0.02	107.58
11-10-77	27	0.06	0.03	0	0.10	51.64
12-6-77	14	0.14	0.02	0.12	0.17	12.62
12-15-77	12	0.34	0.05	0.21	0.38	13.62
12-22-77	26	2.21	0.36	1.72	2.76	16.03
1-4-78	26	1.02	0.06	0.82	1.10	6.06
1-17-78	26	1.12	0.10	0.72	1.20	8.64
1-23-78	27	1.42	0.04	1.37	1.47	3.03
1-26-78	27	1.36	0.15	1.18	1.56	10.77
3-13-78	24	1.41	0.20	1.12	1.64	14.41
4-18-78	23	0.47	0.10	0.30	0.58	21.16
4-26-78	23	0.99	0.05	0.94	1.06	4.91
7-25-78	23	0.50	0.07	0.42	0.60	14.94
9-11-78	23	0.03	0.05	0	0.12	156.35
	No. of events	Mean		Min.	Max.	
Study Period	25	0.49		0	2.76	

TABLE B-9. INDIVIDUAL RAINFALL RUNOFF EVENT NITRATE NITROGEN CONCENTRATION STATISTICS OF RECEIVING STREAM BELOW DRYLOT (SITE 5) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		mg/l				%
5-8-76	20	0.39	0.10	0.27	0.63	25.84
5-22-76	6	0.18	0.04	0.10	0.20	22.27
8-7-76	27	1.55	1.34	0.27	5.70	86.27
1-1-77	27	1.45	0.42	1.11	2.80	29.20
4-30-77	26	1.97	0.32	1.40	2.50	16.50
5-28-77	27	4.20	2.52	0.90	8.60	59.90
6-7-77	24	1.08	0.34	0.50	1.70	30.97
7-3-77	25	1.03	0.33	0.50	1.50	32.36
9-13-77	25	2.59	1.05	1.00	5.20	40.52
9-19-77	27	0.02	0.02	0.01	0.09	91.72
10-17-77	24	1.00	0.47	0.17	1.70	47.02
10-27-77	24	0.51	0.11	0.24	0.65	21.20
11-7-77	27	0.16	0.06	0	0.23	41.34
11-10-77	27	0.91	0.08	0.64	0.99	8.36
11-28-77	26	1.11	0.19	0.69	1.40	17.41
12-6-77	24	1.17	0.08	0.93	1.28	7.00
12-15-77	24	3.26	1.14	1.06	5.50	34.94
12-22-77	26	2.65	0.30	2.07	3.14	11.41
12-30-77	17	2.56	0.18	2.23	2.83	6.86
1-4-78	25	2.78	0.16	2.29	2.96	5.65
1-11-78	23	2.86	0.12	2.63	3.06	4.20
1-17-78	26	2.57	0.17	2.24	2.94	6.66
1-23-78	23	2.53	0.08	2.41	2.62	3.15
1-26-78	23	2.80	0.12	2.59	2.93	4.38
3-13-78	20	2.63	0.40	2.14	3.10	15.31
4-18-78	23	2.20	0.31	1.82	2.56	14.12
4-26-78	27	1.62	0.16	1.40	1.86	10.10
7-25-78	23	2.86	0.66	1.98	3.64	23.10
9-11-78	23	0.80	0.32	0.46	1.30	39.57
	No. of events	Mean		Min.	Max.	
Study Period	29	1.77		0	8.60	

TABLE B-10. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL PHOSPHORUS CONCENTRATION STATISTICS OF RECEIVING STREAM HEADWATERS (SITE 1) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard Deviation s.d.	Minimum min.	Maximum max.	Coefficient of Variation C.V.
		mg/l				%
5-8-76	27	0.07	0.02	0.05	0.16	27.46
5-29-76	27	0.07	0.02	0.04	0.15	32.31
6-5-76	27	0.07	0.03	0.04	0.16	42.35
7-5-76	26	0.09	0.04	0.06	0.23	39.24
7-31-76	12	0.11	0.02	0.08	0.14	21.87
8-7-76	27	0.09	0.03	0.05	0.18	33.96
8-14-76	27	0.08	0.03	0.05	0.16	39.06
10-9-76	26	0.10	0.05	0.05	0.28	49.09
10-16-76	26	0.10	0.03	0.08	0.22	30.53
10-23-76	27	0.09	0.04	0.04	0.19	47.24
10-28-76	27	0.09	0.05	0.04	0.26	57.53
11-7-76	26	0.10	0.05	0.05	0.26	54.30
11-13-76	26	0.09	0.02	0.07	0.15	20.52
11-27-76	27	0.11	0.04	0.08	0.28	36.75
12-11-76	26	0.11	0.04	0.08	0.26	39.76
2-19-77	19	0.09	0.02	0.08	0.18	25.71
4-30-77	27	0.08	0.02	0.05	0.15	27.06
5-28-77	27	0.12	0.03	0.06	0.18	24.24
6-25-77	27	0.10	0.03	0.07	0.23	34.69
7-3-77	27	0.19	0.11	0.10	0.50	55.67
8-16-77	27	0.16	0.05	0.06	0.26	30.30
8-30-77	26	0.14	0.06	0.08	0.30	47.15
9-13-77	26	0.10	0.08	0.04	0.33	77.20
9-19-77	26	0.12	0.05	0.04	0.22	38.63
10-17-77	26	0.11	0.02	0.08	0.15	15.73
10-27-77	26	0.09	0.02	0.05	0.15	24.96
11-10-77	27	0.06	0.01	0.04	0.09	21.85
12-6-77	27	0.11	0.02	0.08	0.14	15.27
12-30-77	26	0.09	0.02	0.05	0.15	24.12
1-4-78	27	0.11	0.03	0.05	0.19	30.84
1-11-78	26	0.05	0.01	0.04	0.08	27.25
1-17-78	26	0.06	0.02	0.04	0.11	27.10
1-23-78	27	0.07	0.01	0.05	0.08	15.26
1-26-78	27	0.18	0.06	0.11	0.26	33.22
3-13-78	27	0.09	0.03	0.06	0.15	29.79
4-18-78	27	0.09	0.02	0.07	0.13	20.22
4-26-78	27	0.12	0.04	0.08	0.19	31.30
7-25-78	27	0.18	0.05	0.13	0.28	28.33
9-11-78	27	0.07	0.02	0.05	0.11	27.40
	No. of events	Mean		Min.	Max.	
Study Period	39	0.10		0.04	0.50	

TABLE B-11. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL PHOSPHORUS CONCENTRATION STATISTICS OF RECEIVING STREAM BACKGROUND REACH (SITE 2) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		---mg/l---				%
5-18-76	16	0.06	0.02	0.04	0.10	23.53
8-7-76	27	0.22	0.04	0.17	0.37	19.60
1-1-77	27	0.24	0.06	0.17	0.38	24.79
4-30-77	25	0.06	0.02	0.04	0.11	36.33
5-28-77	27	0.14	0.06	0.10	0.37	39.12
6-25-77	16	0.12	0.03	0.10	0.23	27.72
8-16-77	11	0.20	0.05	0.08	0.26	24.33
8-30-77	26	0.10	0.04	0.05	0.24	39.92
9-13-77	25	0.08	0.04	0.04	0.15	51.55
9-19-77	26	0.26	0.11	0.15	0.53	42.60
10-17-77	26	0.12	0.01	0.11	0.13	7.28
11-7-77	25	0.05	0.01	0.04	0.08	22.56
11-10-77	27	0.08	0.02	0.04	0.14	28.28
12-6-77	14	0.07	0.01	0.06	0.08	13.72
12-15-77	12	0.10	0.03	0.08	0.19	32.31
12-22-77	26	0.12	0.03	0.08	0.19	24.97
1-4-78	26	0.10	0.03	0.08	0.19	28.00
1-17-78	26	0.06	0.01	0.04	0.08	20.67
1-23-78	27	0.08	0.01	0.07	0.10	11.48
1-26-78	27	0.12	0.02	0.11	0.14	12.35
3-13-78	24	0.12	0.02	0.11	0.15	13.24
4-18-78	23	0.12	0.02	0.11	0.15	13.94
4-26-78	23	0.16	0.06	0.11	0.24	33.46
7-25-78	23	0.29	0.09	0.20	0.41	30.03
9-11-78	23	0.08	0.03	0.04	0.11	39.28
	No. of events	Mean		Min.	Max.	
Study Period	25	0.13		0.04	0.53	

TABLE B-12. INDIVIDUAL RAINFALL RUNOFF EVENT TOTAL PHOSPHORUS CONCENTRATION STATISTICS OF RECEIVING STREAM BELOW DRYLOT (SITE 5) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		mg/l				%
5-8-76	17	0.65	0.09	0.51	0.84	13.83
5-22-76	6	0.53	0.08	0.44	0.67	15.56
8-7-76	27	1.96	2.23	0.34	10.13	113.54
1-1-77	27	1.54	0.52	0.89	2.96	33.77
4-30-77	26	0.93	0.20	0.58	1.41	21.02
5-28-77	27	1.12	0.55	0.48	2.42	49.00
6-7-77	24	0.87	0.15	0.64	1.16	16.76
7-3-77	25	1.51	0.90	0.78	3.90	59.98
9-13-77	25	0.72	0.24	0.53	1.35	33.54
9-19-77	27	0.43	0.06	0.32	0.56	14.56
10-17-77	24	0.59	0.10	0.35	0.79	17.72
10-27-77	26	0.41	0.07	0.23	0.52	17.35
11-7-77	27	0.33	0.05	0.23	0.45	16.18
11-10-77	27	0.58	0.08	0.41	0.81	14.46
11-28-77	26	0.38	0.04	0.26	0.45	10.96
12-6-77	25	0.30	0.07	0.16	0.40	21.68
12-15-77	25	1.46	0.89	0.30	4.13	61.28
12-22-77	26	0.94	0.26	0.58	1.31	27.10
12-30-77	17	0.52	0.08	0.38	0.68	15.84
1-4-78	26	0.42	0.06	0.34	0.55	13.63
1-11-78	23	0.42	0.10	0.29	0.62	24.18
1-17-78	26	0.45	0.08	0.35	0.64	18.33
1-23-78	23	0.24	0.02	0.20	0.26	9.61
1-26-78	23	0.58	0.20	0.38	0.87	34.96
3-13-78	20	0.68	0.33	0.34	1.16	48.37
4-18-78	23	0.62	0.15	0.42	0.80	24.51
4-26-78	27	0.75	0.14	0.61	1.01	18.64
7-25-78	23	0.97	0.12	0.83	1.12	12.16
9-11-78	23	0.64	0.08	0.56	0.79	12.55
	No. of events	Mean		Min.	Max.	
Study Period	29	0.74		0.16	10.13	

TABLE B-13. INDIVIDUAL RAINFALL RUNOFF EVENT CHOLORIDES CONCENTRATION STATISTICS OF RECEIVING STREAM HEADWATERS (SITE 1) DURING STUDY PERIOD

Sampling date	No. of samples taken n	Mean $\bar{x}$	Standard deviation s.d.	Minimum min.	Maximum max.	Coefficient of variation C.V.
		mg/l				%
5-8-76	27	7.99	0.42	7.40	9.30	5.22
5-29-76	27	7.51	1.04	4.00	8.90	13.90
6-5-76	27	7.53	1.58	6.10	12.50	21.00
7-5-76	26	7.19	0.86	4.50	8.20	11.92
7-31-76	12	8.45	0.52	7.70	9.60	6.15
8-7-76	27	8.47	0.46	7.50	9.20	5.40
8-14-76	25	9.00	1.17	7.20	11.90	12.99
10-9-76	26	8.94	0.63	7.00	10.00	7.04
10-16-76	26	8.95	0.72	7.50	10.40	8.00
10-23-76	27	9.24	1.05	6.90	12.20	11.34
10-28-76	27	9.13	1.78	7.00	14.40	19.47
11-7-76	26	7.07	1.40	4.30	8.80	19.88
11-13-76	27	8.11	0.42	7.20	8.80	5.13
11-27-76	27	8.03	0.71	6.70	10.50	8.88
12-11-76	27	7.14	0.57	6.30	8.00	7.95
2-19-77	19	7.45	0.16	7.00	7.70	2.12
4-30-77	2	7.97	0.58	6.50	9.50	7.33
5-28-77	27	7.61	0.26	7.10	8.10	3.48
6-25-77	27	8.47	0.75	7.20	10.50	8.85
7-3-77	27	10.14	1.55	8.20	13.70	15.33
8-16-77	27	10.11	0.27	9.20	11.10	2.70
8-30-77	26	7.53	0.97	5.60	8.90	12.84
9-13-77	26	6.07	1.35	3.00	8.20	22.18
9-19-77	26	8.30	0.30	7.80	9.00	3.64
10-17-77	26	7.78	0.48	6.90	8.50	6.15
10-27-77	26	7.39	0.46	6.60	8.10	6.27
11-10-77	27	8.04	0.29	7.50	8.90	3.62
12-6-77	27	7.25	0.26	6.80	7.70	3.51
12-30-77	26	8.34	0.45	7.50	9.40	5.43
1-4-78	27	6.82	0.43	6.30	8.00	6.35
1-11-78	26	7.04	0.35	6.30	7.50	5.02
1-17-78	26	7.05	0.44	6.10	8.40	6.29
1-23-78	27	6.76	0.22	6.50	7.00	3.18
1-26-78	27	5.64	0.68	4.50	6.50	12.10
3-13-78	27	5.95	1.16	4.50	7.50	19.58
4-18-78	27	8.55	0.29	7.90	9.30	3.42
4-26-78	27	6.49	0.43	5.60	7.30	6.58
7-25-78	27	6.38	0.50	5.50	7.20	7.90
9-11-78	27	6.78	0.61	5.60	7.80	9.06
	No. of Events	Mean		Min.	Max.	
Study Period	39	7.76		3.00	14.40	

TABLE B-14. INDIVIDUAL RAINFALL RUNOFF EVENT CHLORIDES CONCENTRATION STATISTICS OF RECEIVING STREAM BACKGROUND REACH (SITE 2) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		mg/l				%
5-18-76	16	5.38	0.27	5.00	5.80	5.11
8-7-76	27	6.71	0.43	6.10	7.80	6.46
1-1-77	27	8.02	0.44	7.60	9.50	5.51
4-30-77	26	6.67	0.38	5.60	7.20	5.71
5-28-77	27	6.09	0.76	5.00	7.50	12.39
6-25-77	17	6.88	0.49	6.20	8.00	7.14
8-16-77	10	8.21	0.18	8.00	8.50	2.18
8-30-77	26	6.69	0.87	5.10	8.50	12.99
9-13-77	25	7.90	0.73	7.00	9.50	9.24
9-19-77	26	7.75	1.29	5.80	10.90	16.60
10-17-77	26	7.47	0.31	7.00	7.80	4.12
11-7-77	25	7.56	0.51	6.30	8.40	6.72
11-10-77	27	6.36	0.20	5.90	6.60	3.19
12-6-77	14	6.36	0.26	6.00	7.00	4.12
12-15-77	12	5.37	0.42	4.50	6.00	7.84
12-22-77	26	7.20	0.79	5.80	8.50	10.90
1-4-78	26	5.98	0.33	5.50	6.50	5.59
1-17-78	26	5.94	0.24	5.40	6.70	4.13
1-23-78	27	5.59	0.16	5.50	5.90	2.82
1-26-78	27	4.87	0.57	4.20	5.70	11.66
3-13-78	24	5.03	0.90	4.00	6.30	17.80
4-18-78	23	5.05	0.19	4.90	5.30	3.84
4-26-78	23	5.75	0.38	5.30	6.30	6.58
7-25-78	23	5.13	0.28	4.80	5.50	5.46
9-11-78	23	5.37	0.44	4.90	6.00	8.14
	No. of Events	Mean		Min.	Max.	
Study Period	25	6.37		4.00	10.90	

TABLE B-15. INDIVIDUAL RAINFALL RUNOFF EVENT CHLORDIES CONCENTRATION STATISTICS OF RECEIVING STREAM BELOW DRYLOT (SITE 5) DURING STUDY PERIOD

Sampling date	No. of samples taken	Mean	Standard deviation	Minimum	Maximum	Coefficient of variation
	n	$\bar{x}$	s.d.	min.	max.	C.V.
		----------mg/l----------				%
5-8-76	20	7.24	0.58	6.60	8.40	8.08
5-22-76	6	4.62	0.51	4.00	5.10	11.00
8-7-76	27	9.89	2.93	5.70	19.00	29.61
1-1-77	27	12.92	0.82	12.00	15.80	6.39
4-30-77	26	10.11	0.72	8.90	12.10	7.08
5-28-77	27	10.78	3.02	6.00	17.00	28.00
6-7-77	24	10.97	0.65	9.90	12.10	5.92
7-3-77	25	13.26	1.90	11.20	17.50	14.33
9-13-77	25	11.17	0.86	8.50	12.50	7.74
9-19-77	27	10.00	0.40	9.50	11.20	3.98
10-17-77	24	12.06	1.02	9.50	13.30	8.49
10-27-77	26	10.60	0.59	8.90	11.30	5.54
11-7-77	27	10.30	0.80	8.50	11.50	7.72
11-10-77	27	8.94	0.28	8.30	9.40	3.17
11-28-77	26	10.03	0.42	9.50	11.30	4.18
12-6-77	25	10.56	1.08	9.50	13.90	10.24
12-15-77	26	10.59	1.50	8.90	13.90	14.19
12-22-77	26	13.47	0.87	11.50	15.00	6.49
12-30-77	17	11.77	0.57	11.00	13.20	4.87
1-4-78	26	11.01	0.37	10.50	11.90	3.34
1-11-78	24	10.17	0.58	9.50	11.30	5.67
1-17-78	26	9.25	0.38	8.80	10.10	4.14
1-23-78	23	9.35	0.52	9.00	10.20	5.57
1-26-78	23	7.80	0.79	6.50	8.60	10.10
3-13-78	23	7.45	1.17	6.00	8.50	15.74
4-18-78	23	14.22	0.35	13.80	14.80	2.47
4-26-78	27	7.71	0.34	7.10	8.00	4.39
7-25-78	23	8.43	0.71	7.50	9.30	8.41
9-11-78	23	9.08	0.68	8.20	9.80	7.54
	No. of Events	Mean		Min.	Max.	
Study Period	29	10.13		4.00	19.00	

APPENDIX C

CHEMICAL CONSTITUENT CONCENTRATIONS OF RECEIVING STREAM DURING A TYPICAL RAINFALL RUNOFF EVENT

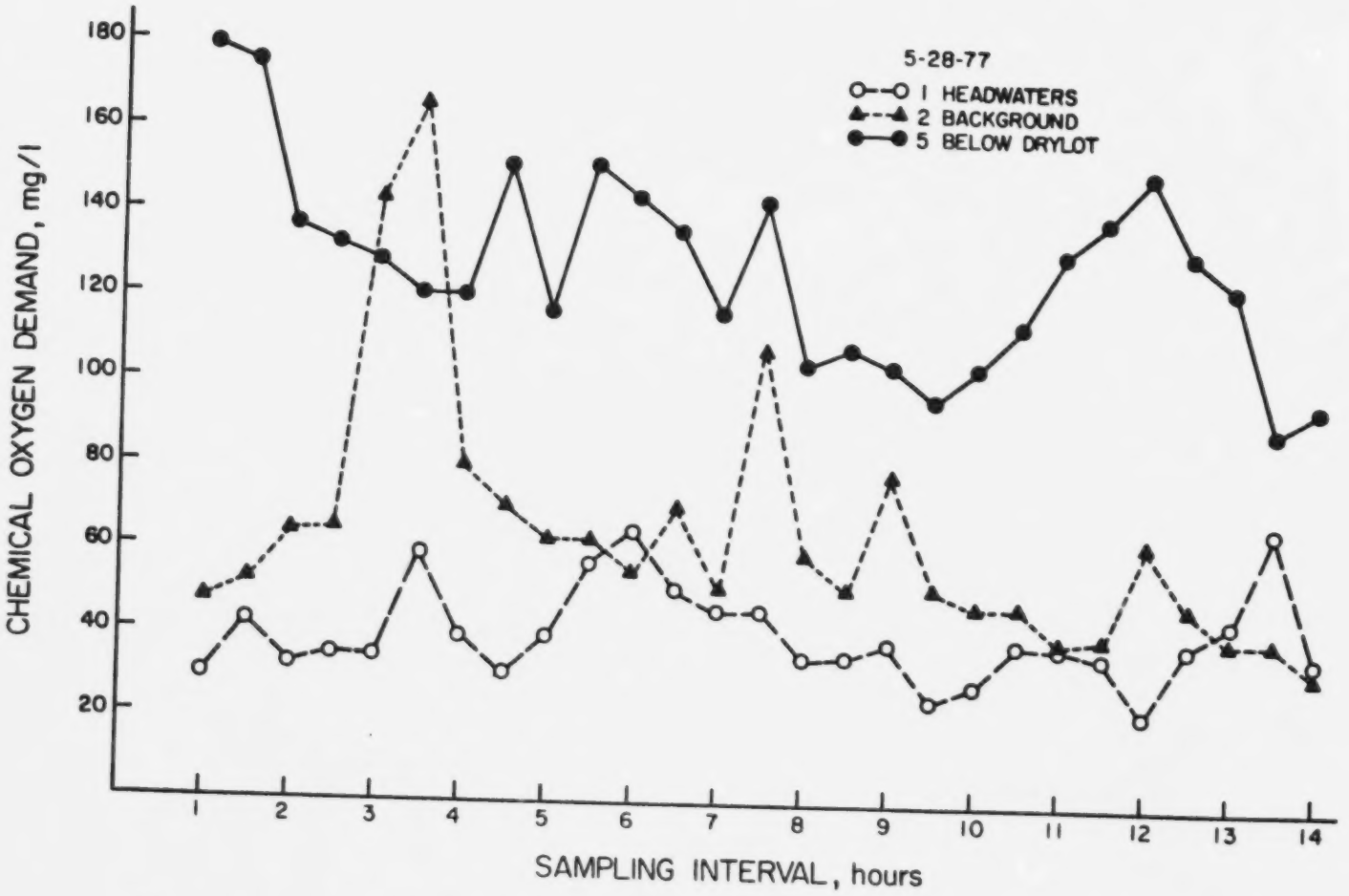

Figure C-1. Chemical oxygen demand of receiving stream during typical rainfall runoff event on 5-28-77.

TABLE C-1. CHEMICAL OXYGEN DEMAND OF RECEIVING STREAM DURING TYPICAL RAINFALL RUNOFF EVENT ON 5-28-77

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	30.94	48.50	217.31
1.0	29.65	47.71	178.85
1.5	42.68	52.29	174.99
2.0	32.51	64.33	136.54
2.5	35.09	65.09	132.70
3.0	34.49	143.13	128.85
3.5	59.54	166.03	121.20
4.0	39.64	80.15	121.20
4.5	31.04	70.61	151.92
5.0	39.73	62.98	117.31
5.5	56.61	62.98	151.92
6.0	65.16	55.34	144.23
6.5	51.00	70.61	136.54
7.0	46.35	51.53	117.31
7.5	46.15	108.78	143.68
8.0	35.27	59.62	105.36
8.5	35.68	51.92	109.20
9.0	39.00	78.85	105.36
9.5	25.74	51.92	97.70
10.0	29.62	48.08	105.36
10.5	39.00	48.08	114.94
11.0	38.68	40.39	132.18
11.5	36.23	40.39	139.85
12.0	22.97	63.46	151.34
12.5	39.00	48.08	132.18
13.0	44.96	40.39	124.52
13.5	67.41	40.39	90.86
14.0	36.23	32.69	96.70
Mean	40.72	64.66	128.25

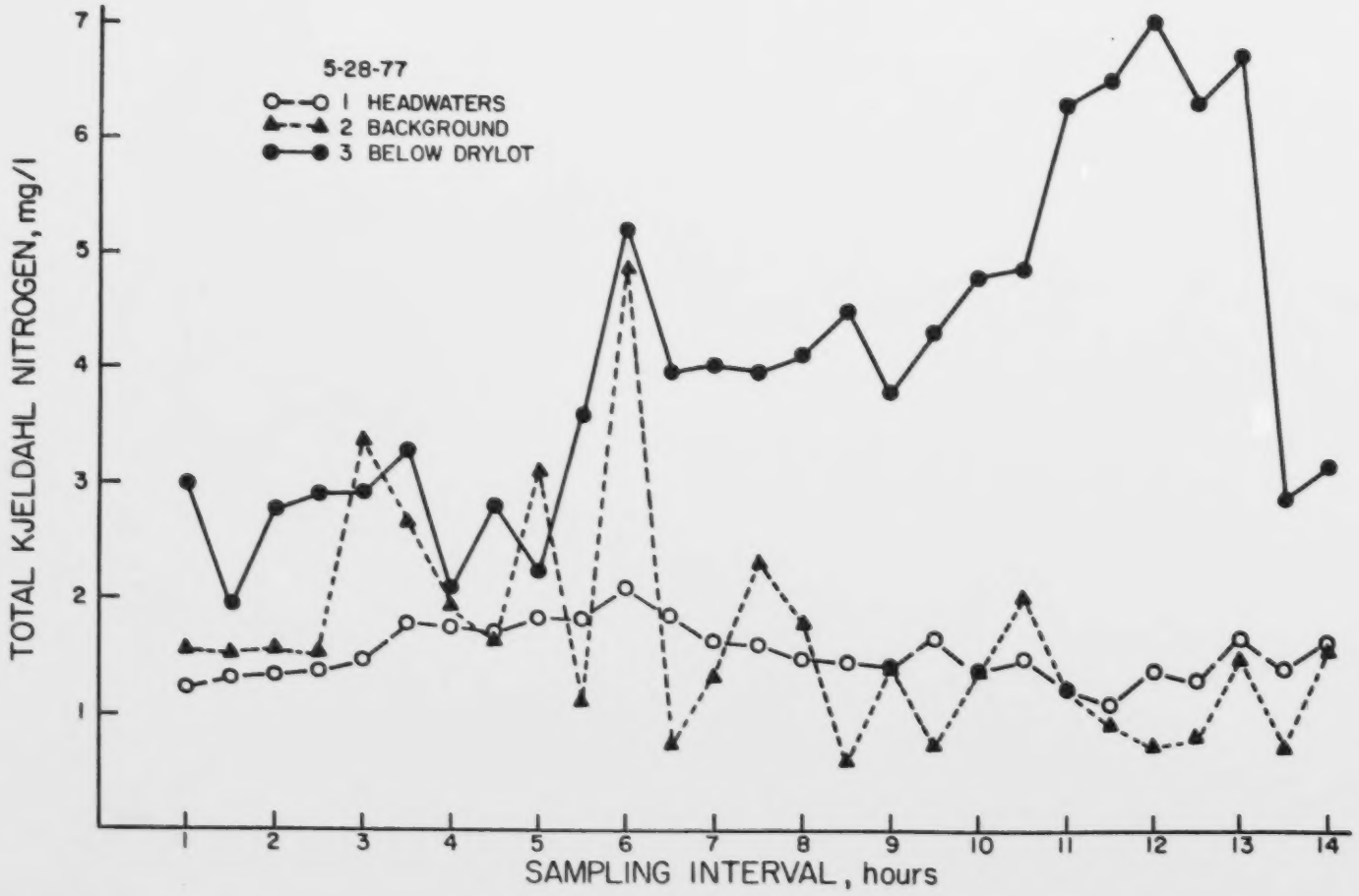

Figure C-2. Total Kjeldahl nitrogen concentrations of receiving stream during typical rainfall runoff event on 5-28-77.

TABLE C-2. TOTAL KJELDAHL NITROGEN CONCENTRATIONS OF RECEIVING STREAM DURING TYPICAL RAINFALL RUNOFF EVENT ON 5-28-77

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	1.24	1.62	3.98
1.0	1.23	1.57	3.00
1.5	1.32	1.53	1.95
2.0	1.35	1.57	2.78
2.5	1.39	1.54	2.91
3.0	1.50	3.38	2.93
3.5	1.79	2.67	3.30
4.0	1.78	1.95	2.10
4.5	1.71	1.65	2.82
5.0	1.85	3.11	2.25
5.5	1.84	1.11	3.60
6.0	2.11	4.88	5.18
6.5	1.87	0.75	3.98
7.0	1.64	1.35	4.04
7.5	1.61	2.33	3.98
8.0	1.49	1.80	4.13
8.5	1.47	0.60	4.50
9.0	1.43	1.41	3.78
9.5	1.69	0.75	4.32
10.0	1.37	1.38	4.80
10.5	1.51	2.03	4.88
11.0	1.21	1.23	6.30
11.5	1.11	0.93	6.53
12.0	1.39	0.75	7.05
12.5	1.31	0.83	6.33
13.0	1.70	1.50	6.75
13.5	1.42	0.74	2.87
14.0	1.66	1.58	3.16
Mean	1.55	1.66	4.08

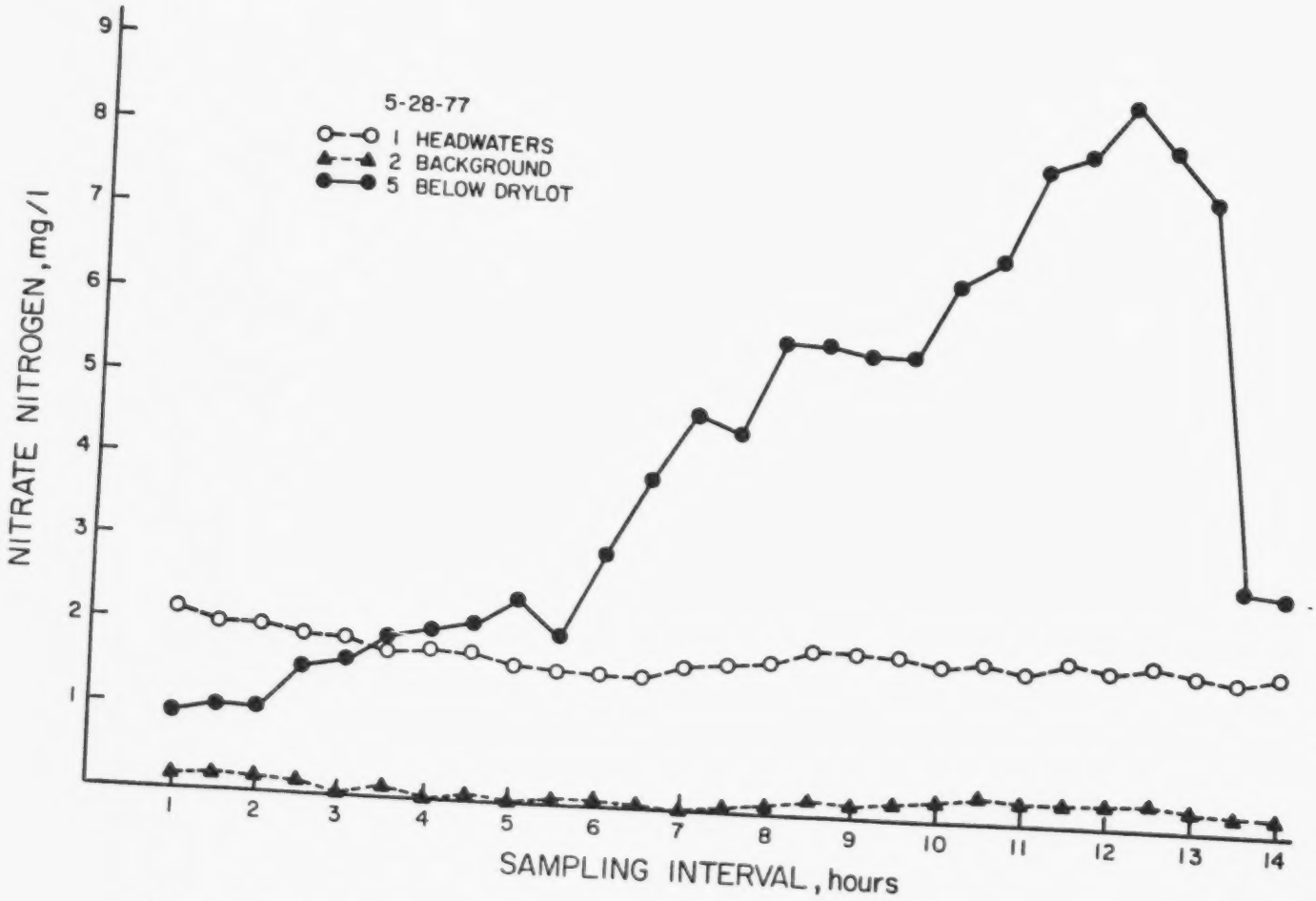

Figure C-3. Nitrate nitrogen concentrations of receiving stream during typical rainfall runoff event on 5-28-77.

TABLE C-3. NITRATE NITROGEN CONCENTRATIONS OF RECEIVING STREAM DURING TYPICAL RAINFALL RUNOFF EVENT ON 5-28-77

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	2.15	0.16	0.90
1.0	2.13	0.14	0.90
1.5	2.00	0.16	1.00
2.0	1.99	0.15	1.00
2.5	1.90	0.14	1.50
3.0	1.87	0	1.60
3.5	1.72	0.11	1.90
4.0	1.76	0	2.00
4.5	1.74	0.05	2.10
5.0	1.62	0.03	2.40
5.5	1.58	0.03	2.00
6.0	1.57	0.08	3.00
6.5	1.55	0.06	3.90
7.0	1.69	0	4.70
7.5	1.73	0.05	4.50
8.0	1.78	0.10	5.60
8.5	1.93	0.17	5.60
9.0	1.96	0.14	5.50
9.5	1.92	0.19	5.50
10.0	1.83	0.23	6.40
10.5	1.89	0.29	6.70
11.0	1.80	0.26	7.80
11.5	1.93	0.25	8.00
12.0	1.85	0.26	8.60
12.5	1.92	0.29	8.10
13.0	1.84	0.23	7.50
13.5	1.77	0.21	2.87
14.0	1.87	0.19	2.82
Mean	1.82	0.14	4.20

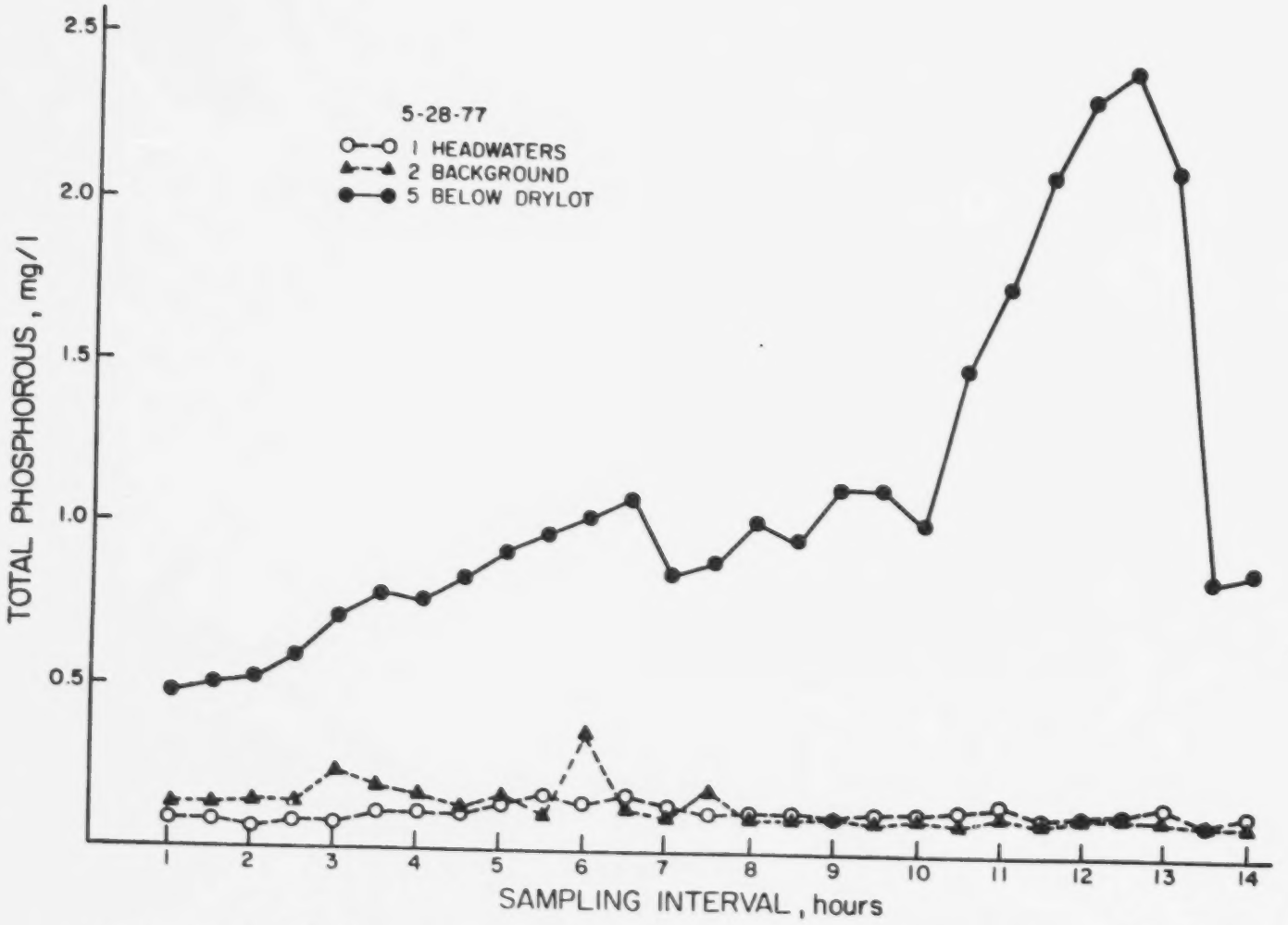

Figure C-4. Total phosphorus concentrations of receiving stream during typical rainfall runoff event on 5-28-77.

TABLE C-4. TOTAL PHOSPHORUS CONCENTRATIONS OF RECEIVING STREAM DURING TYPICAL RAINFALL RUNOFF EVENT ON 5-28-77

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	0.08	0.12	0.51
1.0	0.08	0.13	0.48
1.5	0.08	0.13	0.51
2.0	0.06	0.14	0.53
2.5	0.08	0.14	0.60
3.0	0.08	0.24	0.72
3.5	0.11	0.19	0.79
4.0	0.11	0.17	0.77
4.5	0.11	0.13	0.84
5.0	0.14	0.17	0.92
5.5	0.18	0.11	0.98
6.0	0.15	0.37	1.03
6.5	0.18	0.13	1.09
7.0	0.15	0.11	0.86
7.5	0.12	0.19	0.90
8.0	0.13	0.11	1.05
8.5	0.13	0.11	0.97
9.0	0.12	0.11	1.13
9.5	0.13	0.11	1.13
10.0	0.13	0.11	1.05
10.5	0.14	0.10	1.50
11.0	0.16	0.13	1.76
11.5	0.12	0.11	2.10
12.0	0.13	0.13	2.33
12.5	0.12	0.13	2.42
13.0	0.16	0.13	2.12
13.5	0.12	0.11	0.86
14.0	0.14	0.11	0.89
Mean	0.12	0.14	1.12

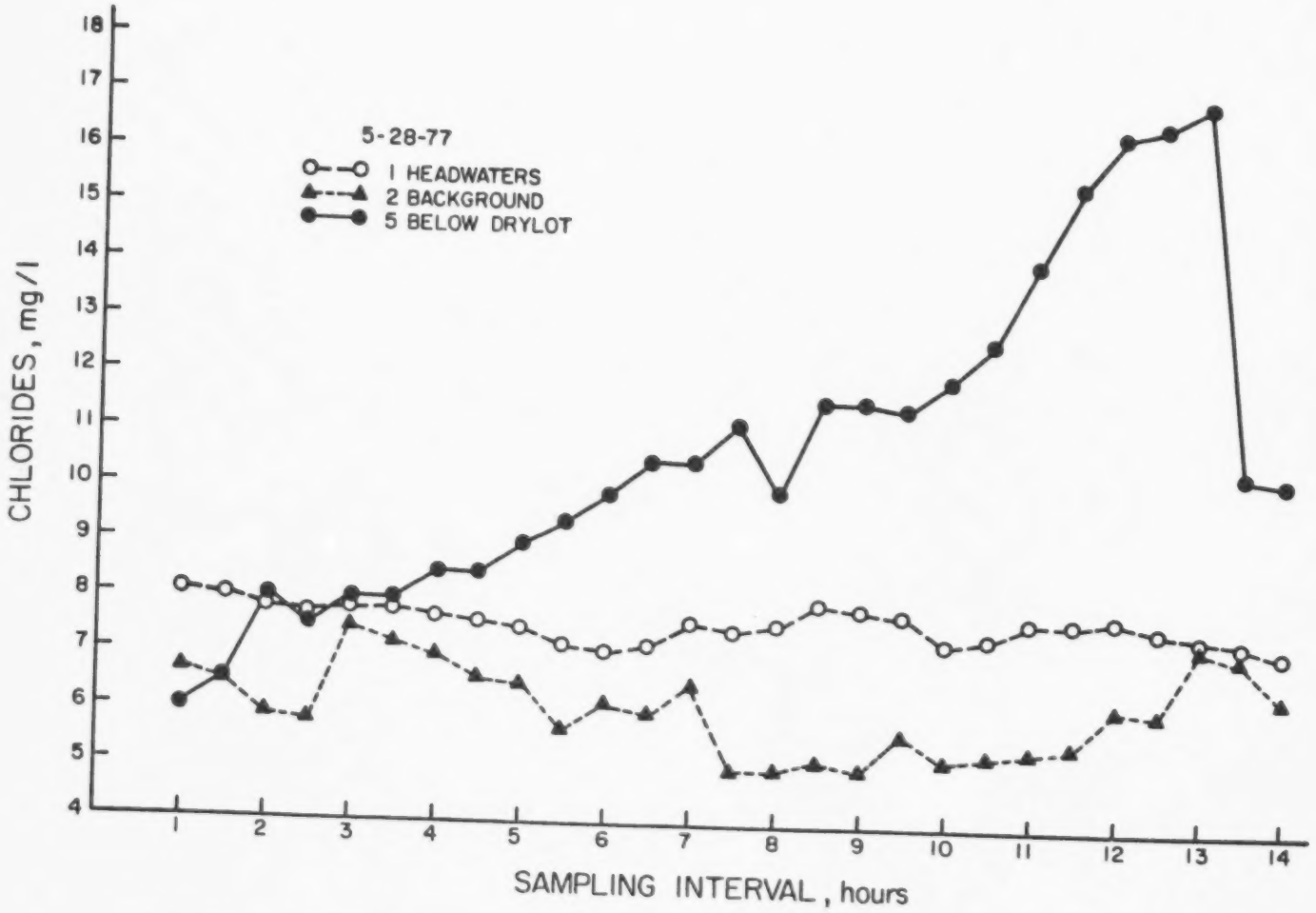

Figure C-5. Chlorides concentrations of receiving stream during typical rainfall runoff event on 5-28-77.

TABLE C-5. CHLORIDES CONCENTRATIONS OF RECEIVING STREAM DURING TYPICAL RAINFALL RUNOFF EVENT ON 5-28-77

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	8.3	6.7	6.5
1.0	8.1	6.7	6.0
1.5	8.0	6.5	6.5
2.0	7.8	5.9	8.0
2.5	7.7	5.8	7.5
3.0	7.8	7.5	8.0
3.5	7.8	7.2	8.0
4.0	7.7	7.0	8.5
4.5	7.6	6.6	8.5
5.0	7.5	6.5	9.0
5.5	7.2	5.7	9.4
6.0	7.1	6.2	9.9
6.5	7.2	6.0	10.5
7.0	7.6	6.5	10.5
7.5	7.5	5.0	11.2
8.0	7.6	5.0	10.0
8.5	8.0	5.2	11.6
9.0	7.9	5.0	11.6
9.5	7.8	5.7	11.5
10.0	7.3	5.2	12.0
10.5	7.4	5.3	12.7
11.0	7.7	5.4	14.1
11.5	7.7	5.5	15.5
12.0	7.8	6.2	16.4
12.5	7.6	6.1	16.6
13.0	7.5	7.3	17.0
13.5	7.4	7.1	10.4
14.0	7.2	6.4	10.3
Mean	7.61	6.09	10.79

APPENDIX D

CHEMICAL CONSTITUENT CONCENTRATIONS OF RECEIVING STREAM DURING AN EXTREME RAINFALL RUNOFF EVENT

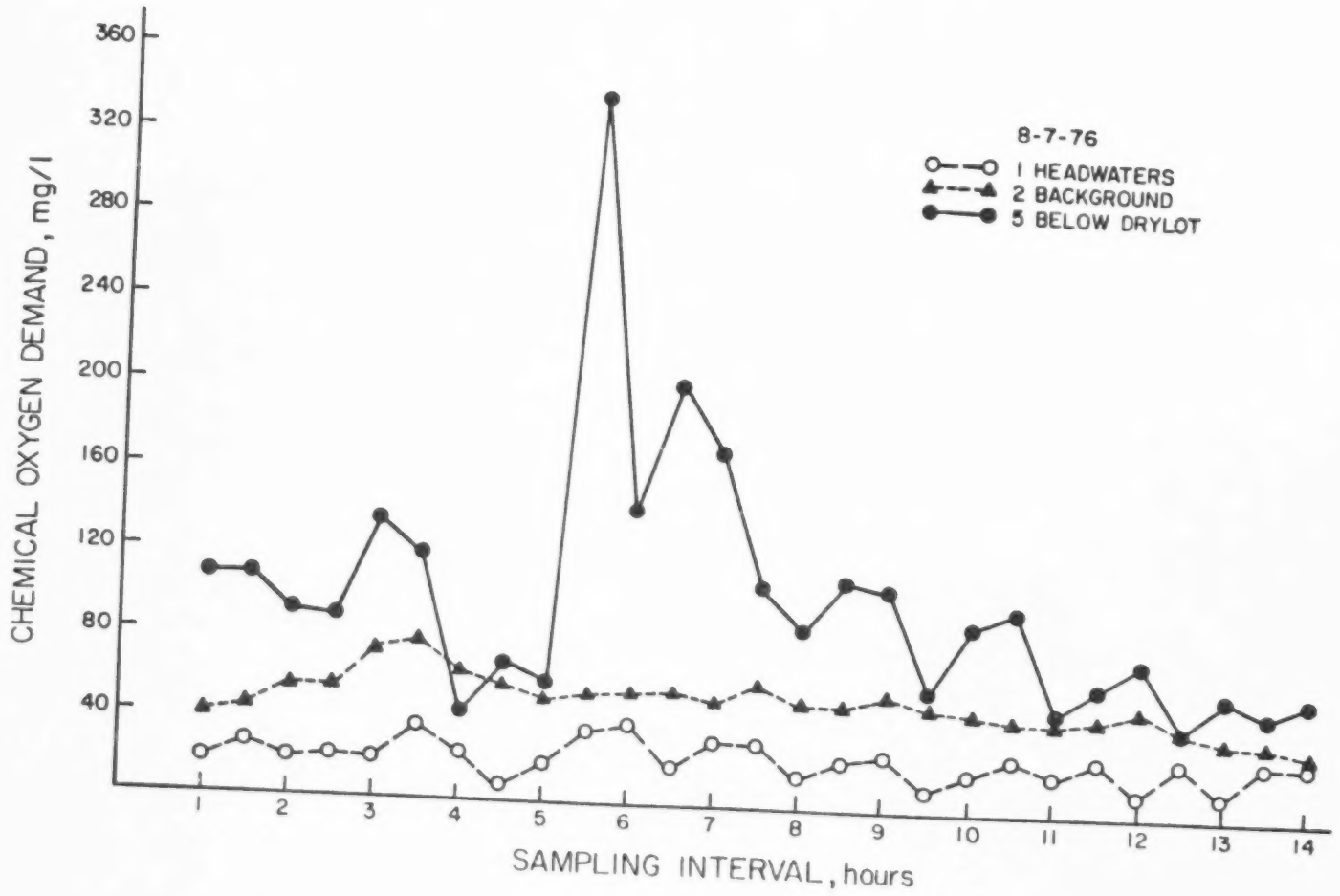

Figure D-1. Chemical oxygen demand of receiving stream during extreme rainfall runoff event on 8-7-76.

TABLE D-1. CHEMICAL OXYGEN DEMAND OF RECEIVING STREAM DURING EXTREME RAINFALL RUNOFF EVENT ON 8-7-76

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	18.74	40.75	120.35
1.0	17.96	40.09	107.62
1.5	25.85	43.93	108.07
2.0	19.69	54.05	91.04
2.5	21.25	54.70	89.15
3.0	20.89	73.21	135.45
3.5	36.07	77.28	119.52
4.0	24.02	63.06	43.82
4.5	8.03	57.02	67.72
5.0	20.10	51.30	59.76
5.5	36.10	53.76	338.60
6.0	40.16	54.94	143.40
6.5	20.10	56.52	203.18
7.0	32.13	52.33	171.30
7.5	32.13	60.94	107.56
8.0	16.06	51.66	87.64
8.5	24.09	51.25	111.55
9.0	28.11	56.66	107.56
9.5	12.05	51.08	59.76
10.0	20.10	49.39	91.63
10.5	28.11	46.28	99.60
11.0	20.10	45.49	51.79
11.5	28.11	46.67	63.74
12.0	12.05	52.71	75.69
12.5	28.11	41.88	43.82
13.0	12.05	38.65	59.76
13.5	28.11	37.78	51.79
14.0	28.11	33.68	59.76
Mean	23.69	51.72	101.86

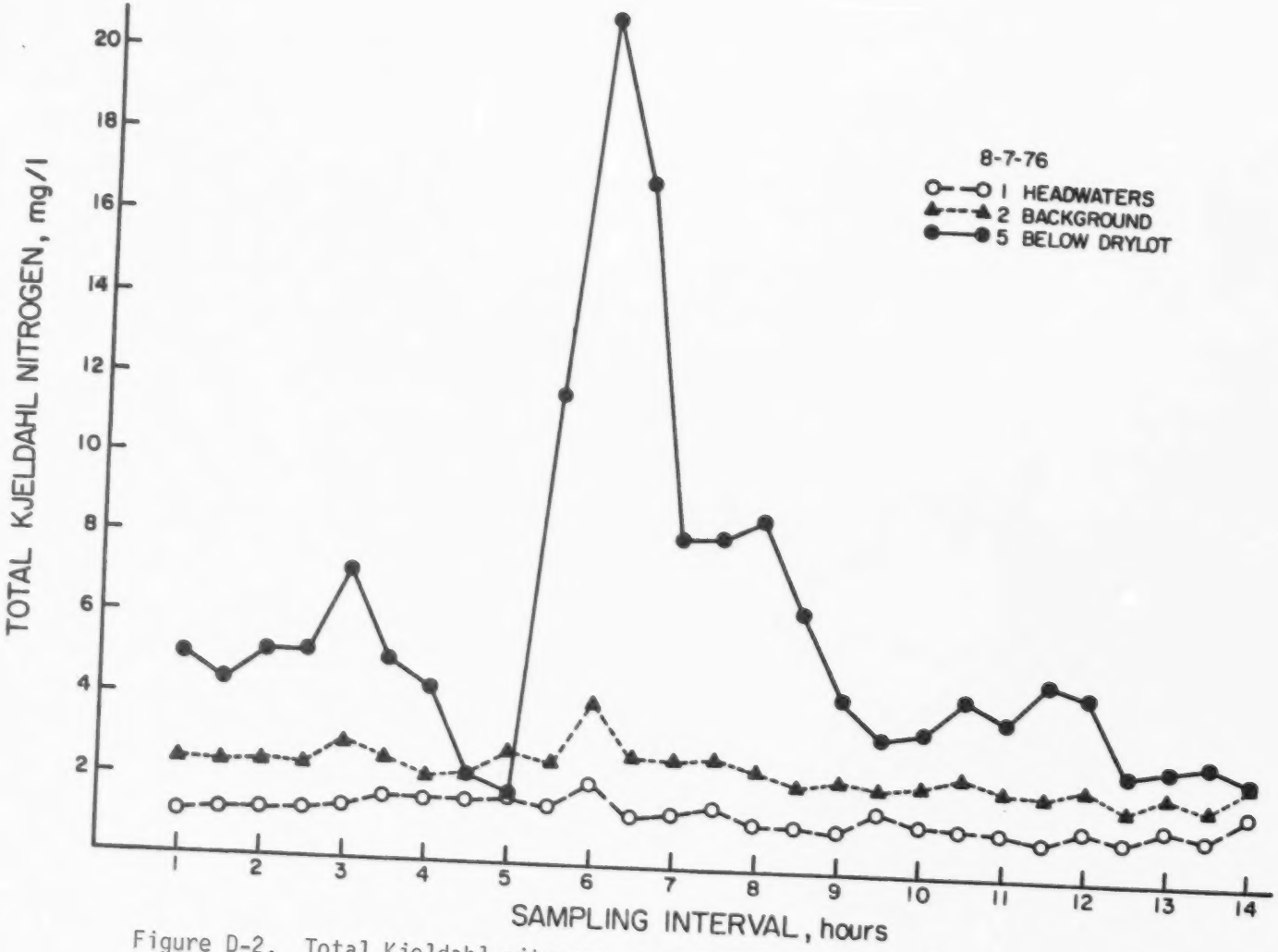

Figure D-2. Total Kjeldahl nitrogen concentrations of receiving stream during extreme rainfall runoff event on 8-7-76.

TABLE D-2. TOTAL KJELDAHL NITROGEN CONCENTRATIONS OF RECEIVING STREAM DURING EXTREME RAINFALL RUNOFF EVENT ON 8-7-76

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	1.11	2.48	5.57
1.0	1.10	2.40	5.00
1.5	1.19	2.35	4.37
2.0	1.22	2.41	5.10
2.5	1.25	2.36	5.12
3.0	1.35	2.93	7.14
3.5	1.61	2.58	4.98
4.0	1.60	2.16	4.32
4.5	1.62	2.26	2.21
5.0	1.65	2.79	1.80
5.5	1.53	2.57	11.70
6.0	2.07	4.12	21.01
6.5	1.31	2.74	17.00
7.0	1.40	2.70	8.16
7.5	1.58	2.79	8.22
8.0	1.20	2.54	8.70
8.5	1.16	2.16	6.42
9.0	1.10	2.31	4.34
9.5	1.58	2.18	3.42
10.0	1.28	2.22	3.59
10.5	1.23	2.49	4.43
11.0	1.16	2.18	3.89
11.5	0.96	2.06	4.86
12.0	1.32	2.31	4.58
12.5	1.05	1.82	2.69
13.0	1.41	2.22	2.87
13.5	1.20	1.92	3.00
14.0	1.76	2.47	2.63
Mean	1.37	2.45	5.98

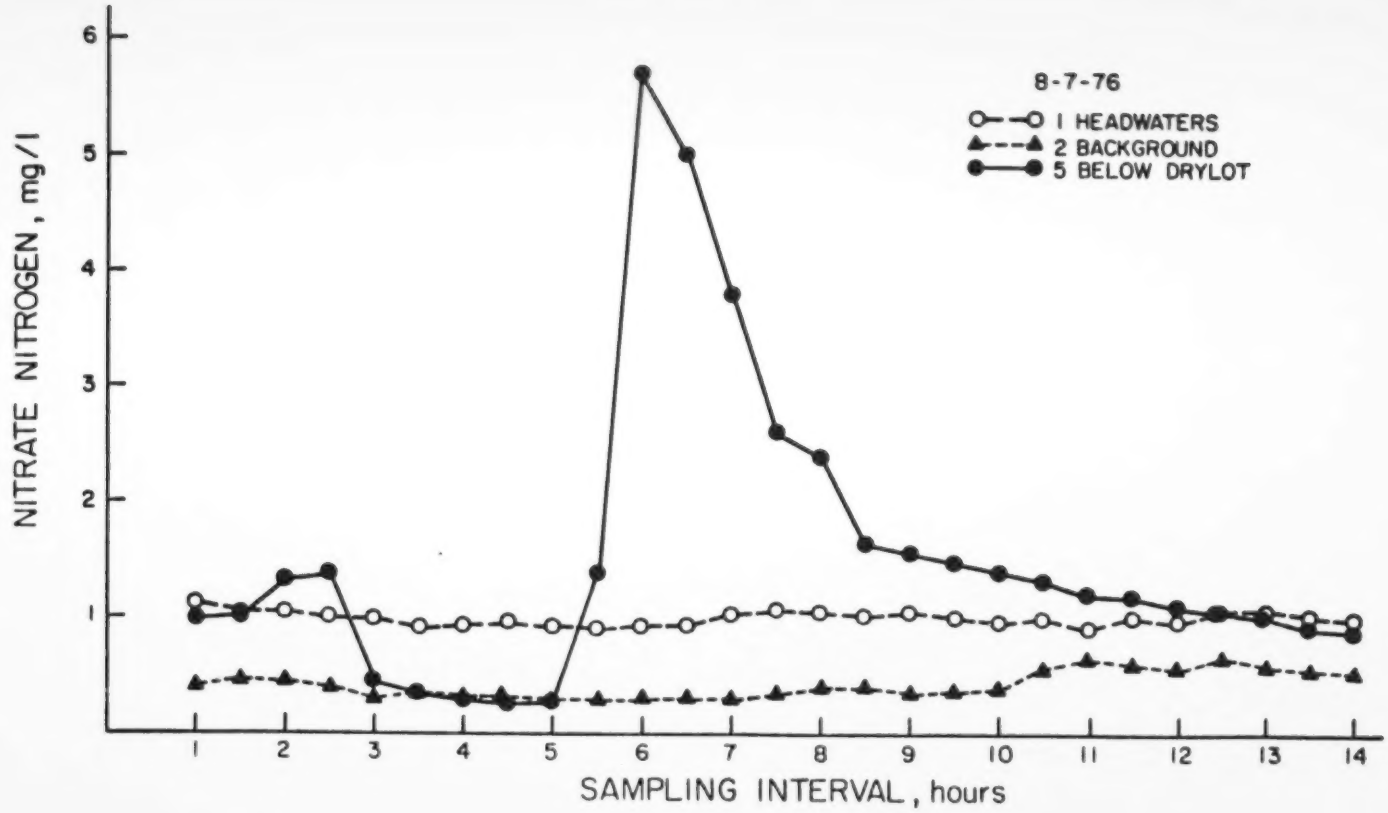

Figure D-3. Nitrate nitrogen concentrations of receiving stream during extreme rainfall runoff event on 8-7-76.

TABLE D-3. NITRATE NITROGEN CONCENTRATIONS OF RECEIVING STREAM DURING EXTREME RAINFALL RUNOFF EVENT ON 8-7-76

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	1.13	0.45	0.97
1.0	1.12	0.40	0.99
1.5	1.05	0.44	1.01
2.0	1.05	0.43	1.32
2.5	1.00	0.39	1.37
3.0	0.99	0.29	0.45
3.5	0.91	0.35	0.35
4.0	0.93	0.30	0.30
4.5	0.96	0.32	0.27
5.0	0.92	0.31	0.27
5.5	0.90	0.29	1.37
6.0	0.93	0.30	5.70
6.5	0.94	0.31	5.00
7.0	1.03	0.29	3.80
7.5	1.06	0.34	2.60
8.0	1.05	0.39	2.40
8.5	1.01	0.40	1.64
9.0	1.04	0.35	1.56
9.5	0.99	0.37	1.47
10.0	0.95	0.37	1.38
10.5	0.98	0.54	1.31
11.0	0.89	0.63	1.19
11.5	0.99	0.59	1.16
12.0	0.95	0.55	1.09
12.5	1.05	0.64	1.03
13.0	1.05	0.56	0.99
13.5	1.00	0.53	0.89
14.0	0.97	0.51	0.86
Mean	0.99	0.41	1.55

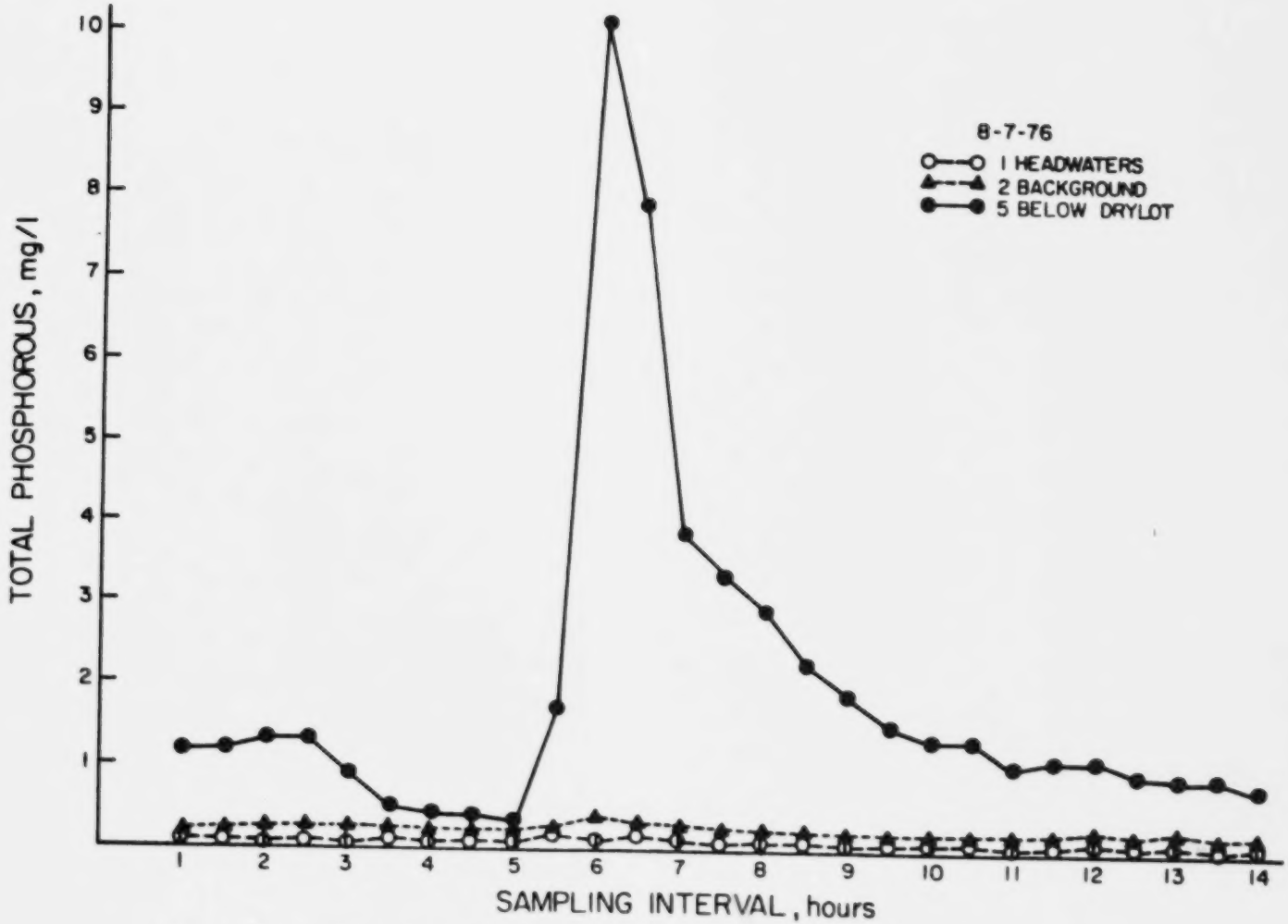

Figure D-4. Total phosphorus concentrations of receiving stream during extreme rainfall runoff event on 8-7-76.

TABLE D-4. TOTAL PHOSPHORUS CONCENTRATIONS OF RECEIVING STREAM DURING EXTREME RAINFALL RUNOFF EVENT ON 8-7-76

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	0.06	0.20	1.17
1.0	0.06	0.20	1.16
1.5	0.06	0.21	1.19
2.0	0.05	0.22	1.31
2.5	0.06	0.22	1.32
3.0	0.06	0.25	0.91
3.5	0.08	0.22	0.51
4.0	0.08	0.21	0.43
4.5	0.09	0.21	0.41
5.0	0.09	0.23	0.34
5.5	0.18	0.25	1.73
6.0	0.10	0.37	10.13
6.5	0.18	0.30	7.90
7.0	0.11	0.28	3.90
7.5	0.08	0.27	3.38
8.0	0.08	0.22	2.93
8.5	0.11	0.20	2.28
9.0	0.08	0.19	1.90
9.5	0.09	0.19	1.54
10.0	0.10	0.20	1.38
10.5	0.09	0.18	1.38
11.0	0.08	0.20	1.06
11.5	0.08	0.19	1.14
12.0	0.09	0.24	1.14
12.5	0.08	0.18	0.98
13.0	0.11	0.25	0.92
13.5	0.07	0.18	0.92
14.0	0.08	0.17	0.79
Mean	0.09	0.22	1.96

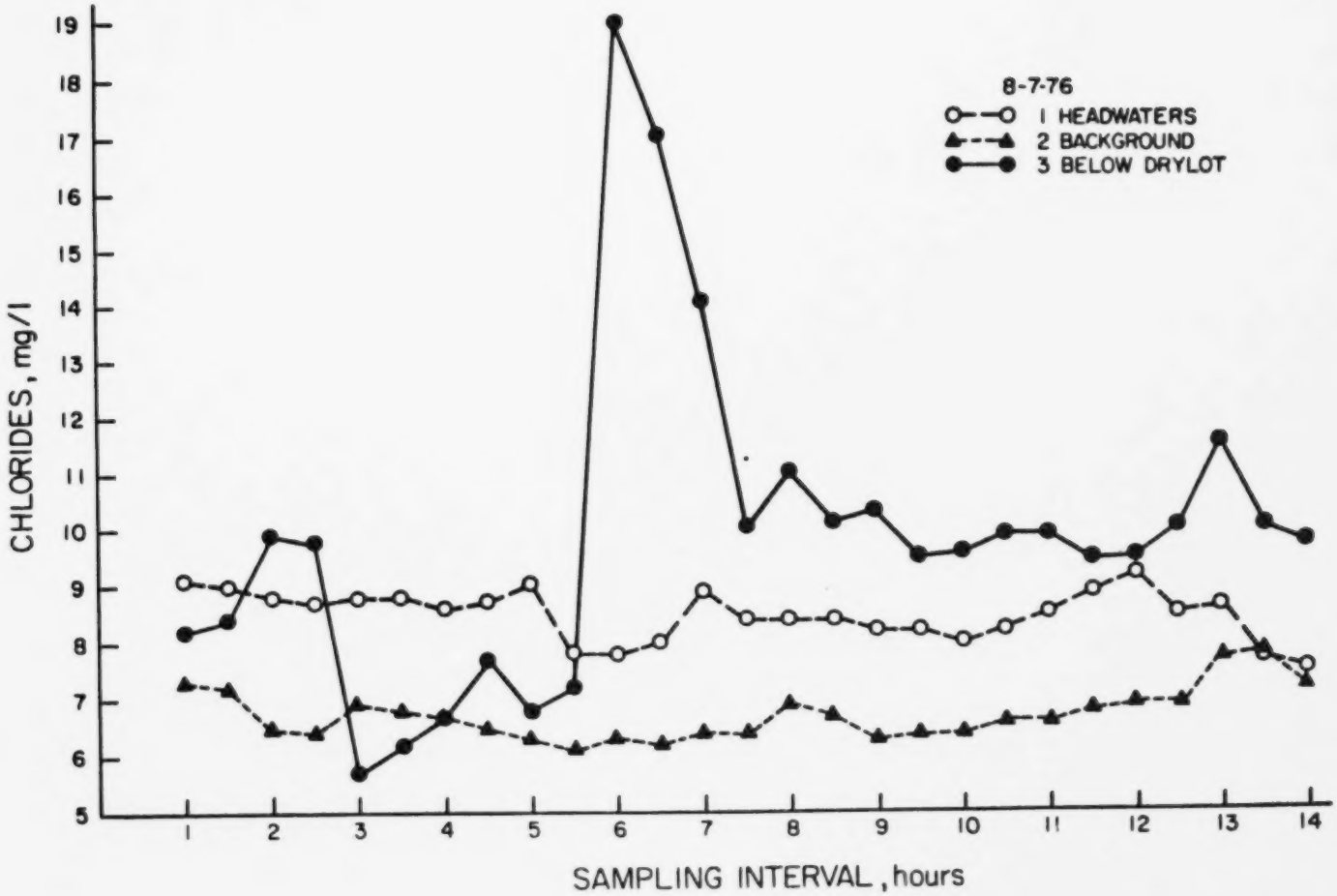

Figure D-5. Chlorides concentrations of receiving stream during extreme rainfall runoff event on 8-7-76.

TABLE D-5. CHLORIDES CONCENTRATIONS OF RECEIVING STREAM DURING EXTREME RAINFALL RUNOFF EVENT ON 8-7-76

Runoff Event Duration	Sampling Site		
	Headwaters 1	Background 2	Below Drylot 5
hours	mg/l		
0.5	9.3	7.3	8.4
1.0	9.1	7.3	8.2
1.5	9.0	7.2	8.4
2.0	8.8	6.5	9.9
2.5	8.7	6.4	9.8
3.0	8.8	6.9	5.7
3.5	8.8	6.8	6.2
4.0	8.6	6.7	6.7
4.5	8.7	6.5	7.7
5.0	9.0	6.3	6.8
5.5	7.8	6.1	7.2
6.0	7.8	6.3	19.0
6.5	8.0	6.2	17.0
7.0	8.9	6.4	14.0
7.5	8.4	6.4	10.0
8.0	8.4	6.9	11.0
8.5	8.4	6.7	10.1
9.0	8.2	6.3	10.3
9.5	8.2	6.4	9.5
10.0	8.0	6.4	9.6
10.5	8.2	6.6	9.9
11.0	8.5	6.6	9.9
11.5	8.9	6.8	9.5
12.0	9.2	6.9	9.5
12.5	8.5	6.9	10.0
13.0	8.6	7.7	11.5
13.5	7.7	7.8	10.0
14.0	7.5	7.2	9.7
Mean	8.47	6.71	9.89